

INTERNATIONAL EDITION

March 2014

Tunnels

AND TUNNELLING

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Western Europe • ISTSS



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ITA TURNS 40

WHEN CONSIDERING an anniversary it is always fun to delve into the archives and see what the past can reveal. The International Tunnelling Association's 40th birthday is no exception and when routing through the early editions of *Tunnels* we happened across an interview with Alan Muir Wood ahead of the first ITA meeting in Oslo, 1974.

The challenges facing the industry then will be familiar to a tunneller embarking on his career today. Tunnelling in mixed ground was the dominant issue of the day and finding a 'universal tunnelling machine' that could cope with any ground, and any mix of ground conditions in the face, Muir Wood ruled out. However, through international cooperation, he thought, the tunnelling industry could develop a more extensive understanding of ground prediction, to replace the practice of cover-drilling ahead of the tunnel face.

Ideals of underground infrastructure to support garden cities above were as much dreamed about in 1974 as today, and tunnellers were as realistic then about achievability as we are now.

But the primary focus of the ITA, in the mind of Muir Wood who was elected chairman at the Oslo meeting, was education, both within the industry and externally. To "enlighten people contingent on the tunnelling world as to the potential of tunnelling". He told *Tunnels* in the May 1974 issue that "quite often the initial planning of a project or of a complex, in which tunnelling might play a part, is masterminded by those completely out of touch with its potential and how it might be put to best effect. In addition, there remains a certain amount of reproduction of methods used one or more generations ago which may be highly uneconomic at the present day."

With this in mind the opening meeting of the ITA set out its aims: "To encourage the planning of the use of subsurface and to promote advances in the preparatory investigations for tunnels, and in the design, construction and maintenance of tunnels, by bringing together information thereon and by studying questions related thereto.

The Association declared that it fulfils its mission through:

Jon Young
Editor



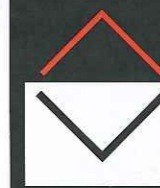
- A. Interchange of information among its adhering National Organisations
- B. Holding meetings at intervals
- C. Organising studies and experiments
- D. Publication of documents

Those familiar with the ITA's activities will know that it can easily claim to have fulfilled its mission, not least through the ever growing World Tunnel Congress, the latest of which is taking place in May in Brazil, which brings together a greater diversity of tunnelling knowledge than any other gathering of tunnellers. The past 40 years have seen massive development within the tunnelling industry and the ITA has been core to guiding and celebrating these advances.

At the May 1974 meeting, *Tunnels and Tunnelling* was asked to act as a focus for enquires about the ITA and help channel material through to the secretariat. Since that meeting we have watched and reported on the efforts of the ITA to steer the industry into a more prosperous future. The *Tunnels* team would like to congratulate the ITA on a very successful 40 years and wish all success for the next 40.

editor@tunnelsonline.info

What do you think? Send your views to the editor and join the debate



This month...

10 YEARS AGO

A joint venture of Japanese firms Taisei Corp and Kumagai Gumi, with Turkish contractors Gama Endustri and Nurol Insaat has been awarded a USD 832M contract to construct the Bosphorus Strait rail tunnel, connecting the European and Asian sides of Istanbul (T&T July 2003). The Marmaray project is a 76km-long upgrade to the rail link across Istanbul, of which 1.8km is an immersed tube tunnel across the Bosphorus River, and 11km are running tunnels to be excavated by TBM and cut and cover. The tunnel phase of the project is being financed by the Japan Bank for International Cooperation (JBICA). The second phase, linking the tunnel to the existing rail lines is expected to cost USD 700M.

Tunnels and Tunnelling, March 2004, p.14

20 YEARS AGO

The legacy of bone necrosis from past compressed air tunnelling continues to dog the industry. In February Balfour Beatty made a GBP 200,000 out of court settlement to a man who worked on the Second Dartford Tunnel in the UK. His condition was alleged to have been aggravated by his work in Hong Kong. A spate of additional claims are expected following the discovery of medical records relating to work on both the Dartford tunnel and the Tyne pedestrian tunnel between 1948 and 1952. Some cases have been dropped or settled out of court, others are still current.

Tunnels and Tunnelling, March 1994, p.7

Cover

The exploratory works for the Lyon-Turin base tunnel are well underway, despite protests, in the Val di Susa



Next issue

In the next issue, *Tunnels* looks to the South East Asian tunnelling market with analysis from WMI's economics arm Timetric, a look at Singapore's urban expansion plans, and also the much-discussed MRT works in Malaysia, featuring the first VFD breakthrough

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DELHI METRO: 8 EPBMs FOR PHASE III

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Corporate and personnel changes, key decisions and financial news from global tunnelling companies
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Antonio Raschilla et al, Systra
M Bufalini et al, LTF
The Lyon Turin high speed rail connection calls for a base tunnel under Mount Ambin. Personnel from site manager Systra, and client Lyon Turin Ferroviaire discuss plans for La Maddalena exploratory tunnel, the organisational structure of the stretches of line, and problems that have dogged the project since before site handover
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The Croix Rousse Tunnel rehabilitation and expansion project in Lyon, France had a number of technical considerations to overcome. This article is drawn from material provided by Vinci

Geological prediction

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Alex Conacher, deputy editor
A look at the methodology, advantages and comparison of the Tunnel Seismic Prediction system provided by Amberg, and the geoelectric offering of GET: BEAM

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With underground infrastructure vulnerable to a number of security threats including fire and terrorist attack, SP Technical Research Institute of Sweden has established a regular tunnel symposium attracting more than 200 delegates from around the world
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Allard Klok, Trainingproducties
An awareness of internal and mental processes relating to stress and fatigue is important when preparing for how people will react in a crisis situation. In an unusual twist, Allard Klok a training course leader for tunnelling, looks not at tunnel user behaviour, but operator behaviour when the pressure is on in a crisis situation



Contributors

Thomas Dickmann

Thomas Dickmann heads up the geophysics department at Switzerland-based engineering firm Amberg Technologies. Last year his department unveiled its newest technology, a three-dimensional update to the Tunnel Seismic Prediction system. He previously worked as a research associate in marine geodynamics for IFM-Geomar, an German institution for marine geosciences. He attended the University of Hamburg, and then earned his PhD in Geophysics at the University of Kiel in northern Germany. In this issue, Thomas contributes to the technology report on geological prediction ahead of the face, which can be found on page 36.

Arnim Kaus

Arnim Kaus is an expert in geology and geophysics, and works as the managing director of Geo-Exploration-Technologies (GET) leading a team of 10 engineers. It was Kaus who originally patented the Bore-tunnelling Electrical Ahead Monitoring system, better known as Beam. The company, GET, performs state-of-the-art ground-based geophysics for geotechnical projects on tunnel sites. In this issue, Arnim contributes to the technology report on geological prediction ahead of the face, which can be found on page 36.

Wolf Boening

Wolf Boening leads GET from its headquarters in Mainz, Germany with his colleague Arnim Kaus. His background is economics, and he is involved in the marketing of the BEAM system. In this issue, Wolf contributes to the technology report on geological prediction ahead of the face, which can be found on page 36.



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GRANDS PROJETS

CHINA DRAFTS USD 36BN TUNNEL PLAN FOR BOHAI SEA LINK

China China has announced plans to build the world's longest underwater tunnel beneath the Bohai Sea by 2026, with a blueprint expected to be submitted to the State Council in April. "If approved, work could begin as early as 2015 or 2016," Wang Mengshu, a tunnel and railway expert at the Chinese Academy of Engineering who has worked on the plan since 2012, told China Daily on 14 February. The project will cost an estimated CNY 220bn (USD 36bn), he said, and work on a feasibility report could take two or three years. The 123km underwater tunnel will house a rail line connecting the port cities of Dalian in Liaoning province and Yantai in Shandong province, according to the plan. Its planned life span will be about 100 years. It will far surpass the combined length of the world's two current longest underwater tunnels -- Japan's Seikan Tunnel linking Honshu and Hokkaido, and the Channel Tunnel between Britain and France. "Using the tunnel, it will take only 40 minutes to travel from Dalian to Yantai," Wang said. At the moment it is a 1,400km drive or about eight

hours by ferry. Passenger vehicles can be loaded onto rail carriages and transported at about 220km an hour, massively shortening the travel time between the two cities, according to the plan.

Wang said the project will consist of two underwater tunnels, both about 10m in diameter, and a service tunnel for maintenance and emergency vehicles about 7m in diameter.

Authorities in Shandong and Liaoning are hoping the project will stimulate economic growth by connecting the northern area with the wealthy eastern coast. The project has been proposed at the National People's Congress and the Chinese People's Political Consultative Conference every year since 2009.

The project was mentioned in Shandong's regional plan approved by the State Council in 2011.

Research by Ludong University in Yantai showed daily traffic flow between Dalian and Yantai is expected to increase to more than 100,000 vehicles by 2015, which will pose a challenge for capacity.

Liu Zhongliang, a professor involved in the research, said the tunnel is expected

to bring profits of CNY 20bn a year and boost tourism in surrounding regions.

"The project could pay for itself within 12 years," Wang said. He added the Bohai Sea tunnel is a critical part of the country's 5,700km railway project to link the cities of Tongshan in Heilongjiang province and Sanya in Hainan province.

The Bohai tunnel will be built at least 30m below the seabed, which is mostly hard rock. Two major fault zones are in the region, posing a risk. The Tanlu, and Zhangjiakou Penglai faults have been sources of chronic seismic activity. The Tangshan earthquake in 1976 killed tens of thousands of people.

Matthias Loftsson, director of geology for Iceland's Mann-vit highlighted safety concerns.

"In general, though, one can say tunnels are not unsafe in earthquake areas, all depending on the geology, tunnel depth and other local conditions,"

"However, excavation of a tunnel through active faults, where displacement can occur with a potential danger of flooding, would be of great concern and needs special attention," Loftsson said.

Crossrail worker dies on Holborn worksite

Great Britain A worker has died on the Crossrail project in London. The man was pronounced dead at the scene after London Fire Brigade and ambulance crews arrived at the Fisher Street site in Holborn early this month.

Crossrail announced a full investigation into the facts of the incident. It is known that the worker sustained head injuries around 10m down the tunnel.

Crossrail released the following statement: "Sadly, at approximately 5am this morning a contractor working at our site in Fisher Street, London was fatally injured. Our first and foremost thoughts are with the family and friends affected by this. The family has been informed.

"When the incident occurred, work was taking place to build a new crossover tunnel between two train tunnels that have already been constructed by Crossrail's boring machines. "The worker was spraying concrete onto the excavated ground when a piece of concrete from the ceiling of the tunnel fell and hit him.

"Crossrail has suspended all work at Fisher Street and associated works across the project.

"A full and thorough investigation into this tragic incident is being undertaken. The Metropolitan Police and the Health and Safety Executive remain on site."

"Safety is our number one priority and Crossrail sets the most stringent safety requirements in the industry. Despite this terrible incident, Crossrail's accident rate is below the industry average."

Tunnel starts in St Louis

USA SAK Construction launched the 11.25ft diameter TBM mining the Lemay Redundant Force Main in St Louis, Missouri, for the Metropolitan St. Louis Sewer District (MSD).

The 3,028ft long tunnel will be excavated primarily through limestone. The project will allow the Lemay Wastewater Treatment Plant to accept a higher volume of wastewater, and allow MSD to inspect the original Force Main for the first time since its construction in the 1960s.

SAK has launched the TBM from a southern shaft, some 175ft deep, and breakthrough on the tunnel at the northern shaft, approximately 128ft (39m) deep, is anticipated for mid-April. The TBM was most recently used on El Encanto HEP, an 8,202ft Main

Power Tunnel in Miramar, Costa Rica in 2009, and was previously deployed on tunnels in Guatemala and the Dominican Republic.

Shannon & Wilson is the construction manager for the Lemay project.

The firm will provide design review and construction management for the Jefferson Barracks conveyance and storage tunnel and Lower Middle River Des Peres conveyance and storage tunnel.

In December, Black & Veatch announced MSD had selected a BV-lead team to manage the construction of more than USD 500M in future tunnel projects to address sewer overflows.

The team is responsible for construction management of up to seven different tunnels. The tunnels will range from 9ft (2.7m) in diameter to more than 20ft (6m).

Windsor-Detroit tunnel could start in 2014

USA-Canada David Cree, president of the Windsor Port Authority, said construction of a new multi-million-dollar rail tunnel between Windsor and Detroit could begin later this year.

Continental Rail Gateway (CRG) is a planned major rail tunnel project underneath the Detroit River connecting Detroit in the US and Windsor in Canada. It is being designed to handle double-stacked containers and tall rail cars.

The proposed crossing would include a 2,845m long tunnel with an 8.4m internal diameter 15m below the river. Environmental assessments and permits from both the

US and Canada are expected mid-year Cree said to local media. Finalizing the funding would be the final step.

CRG is a public-private coalition called formed in 2010 that includes the Windsor Port Authority, Borealis Infrastructure Trust and Canadian Pacific. The estimated cost of the project is USD 400m.

The project partners will fund 50 per cent of the project cost and the remaining half will come from government sources.

Bangkok receives micro delivery

Thailand The JV of Ch. Karnchang PCL and Krung Thon Engineers Co.,Ltd. (KTE) has acquired a Terratec

micro tunnelling system for use on an underpassing of the Bang Pakong River in Bangkok, TBM manufacturer Terratec announced last month.

The complete project will see the installation of 53kms of water transmission pipe lines to transfer raw water from the East side of the Chao Praya River to the Bang-Pra Reservoir.

Included in this is the pipe jacking works crossing the Bang Pakong River which spans 380m in width.

Water sent to the reservoir will be treated and distributed to support many industrial estates at the Eastern Sea Board area which constitutes the largest industrial area in the country.

KTE plans to start the pipejacking work early next month.

Truck sets off Sydney tunnel sprinklers

Australia Sydney's Eastern Distributor tunnel was closed southbound at Moore Park last month, after a truck knocked the sprinklers on in the tunnel, local press reported.

Police said the truck appeared to be over height and reports said its tip tray was up. The truck was removed several hours later and all southbound lanes reopened.

Traffic backed up for some 6.5km following the incident.

Hitachi Zosen fly in to Seattle for Alaskan Way Viaduct TBM fix

USA Seattle Tunnel Partners (STP), the design-build contractor for the Alaskan Way Viaduct replacement tunnel in Seattle, will dig an access shaft to repair or replace the TBM seal. Client Washington State Department of Transportation (WSDOT) said last month that experts from Japanese TBM manufacturer Hitachi-Zosen were flying from the company's factories to

finalise the repair plan.

STP has received proposals from various firms to design the shaft, which will be 100ft (30.5m) deep by 80ft (24.4m) wide.

"While STP has shared their preferred method for accessing the seal system, they are waiting until after their meeting with Hitachi to provide WSDOT with an official plan," WSDOT said in a release.

"Because this is a design-build contract, STP and their machine manufacturer are responsible for developing and implementing the plan to fix the machine and resume tunnelling."

STP has not yet fully determined the cause of the seal problems, though anticipates the plan for repair to be finalized by end of February.

"We can't forecast what the delay might be," said Chris Dixon, project manager for STP. "What we really need to do is determine what we need to do at this juncture and how soon we can resume tunnelling."

The 57.5ft (17.5m) diameter TBM stopped working on December 6, 2013. WSDOT and STP have identified two contributing factors: a clogged cutterhead and high-temperature readings indicating "there were other factors to explore."

Tunnel workers performed 158 hours of hyperbaric inspections in January, the cutterhead clogged with dirt and other material.

After the cutterhead was unclogged, STP moved the machine forward an additional 2ft (0.61m) installed one ring of lining. On January 28 and 29, higher-than-normal heat sensor readings appeared like they did in December.

In the course of investigating the temperature readings, STP discovered damage to the seal system that protects the tunnel boring machine's main bearing.



KVMRT PROJECT

Sungai Buloh to Kajang Line
Kuala Lumpur, Malaysia

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CR50 completed first drive on 24 December 2013 – rates up to 345 m/month

CR51 completed first drive on 16 January 2014 – rates up to 330 m/month

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HS2 APPOINTS CONSTRUCTION CHIEF

Great Britain Simon Kirby has been appointed as CEO of HS2 Construction. Kirby joins from Network Rail where he was managing director of infrastructure projects, leading on a GBP 5bn (USD 8.2bn) a year investment programme to improve the UK's railways.

Kirby will be taking over Alison Munro, who will continue in that role until September this year when she will become managing director of development to oversee the passage of the hybrid Bill through parliament and the development of Phase Two of the project.

New HS2 chairman, David Higgins, said: "As I start my tenure as chairman of this essential project that will free up much needed capacity on our crowded railways, I am extremely pleased that we have secured Simon to run what will be the biggest infrastructure project in Europe, and one of the biggest in the world.

"Delivering this project in a way that is not just cost-effective, but also delivers its benefits to as much of the country as soon as possible, is a huge engineering project, but Simon has proven throughout his career that he is capable of taking on such a unique challenge.

"I fully realise that the skills he brings to the task are much sought after throughout the world and we are delighted he has agreed to take on the role - and that Alison Munro has agreed to continue in her role of over-seeing both the parliamentary process and the development of Phase Two.

"HS2 has the potential to rebalance the UK economy, easing pressure in the south, and opening up the possibility of growth in the north. We are fortunate to be able to call on the skills and commitment of both Simon and Alison to make that potential a reality."

FLOOD WATER TUNNEL CONTRACT SIGNED

Indonesia State-owned construction company PT Wijaya Karya (WKA) has signed a work contract with the Public Works Ministry to construct a giant tunnel connecting the Ciliwung River with Jakarta's East Flood Canal (KBT).

Public Works Minister Djoko Kirmanto said that the project will cost IDR 500bn (USD 41M), and the state firm would be given 14 months to complete the work.

"The 1.27km tunnel with a capacity of at least 60cu.m of water per second can lessen the load of the Ciliwung River, which annually overflows and causes flooding," he said.

The project will start in densely populated neighborhoods on Jl. Sensus Raya and Sekolah Tinggi Ilmu Statistik on Jl. Otto Iskandardinata in East Jakarta.

Djoko said the city administration would be charged with relocating residents affected by the project.

The head of Ciliwung and Cisadane rivers' control office at the ministry, T. Iskandar, said relocations would begin during the second phase of the project.

Djoko said the contract inked covered the first phase of construction. "We will begin the second phase, comprising building inlet, outlet

and normalizing Cipinang River after the first phase is finished," he said, adding that the ministry expected to start the second phase this year (2014).

"If we get additional funds mid-year and the tender process can start immediately, we can do it," he said.

Djoko hoped that WKA would start and finish the project on time.

"So far, we have been ahead of schedule during the preparation and bidding stages," he said.

The city administration has prepared several low-cost apartments near the Ciliwung River to relocate roughly two thousands families.

WKA director Budi Harto claimed that the construction would not severely affect traffic.

"Pipe jacking will be used," he said, explaining that pipe jacking is a pipes and casing installation method that does not use trenches; thus, the contractor would not need to dig up the whole tunnel but only a few spots.

"We only need a small plot of land in the middle of Jl. Otto Iskandardinata," he said.

Budi said the concrete pipe would be provided by a WKA subsidiary while the drilling tools would be sent from Japan in March.

Sir Neville Simms, and lead the development of a new company that would be responsible for the financing and delivery of the landmark project. The process for the procurement of this new company is already in motion, following the issue of a preliminary notice to the market on 6 January 2014.

Simms said: "The Thames Tideway Tunnel must continue to showcase all that is best about Britain's capability to deliver complex civil engineering projects, on time and to budget. In Andy, we are privileged to have the services of a highly-skilled individual, who has been instrumental in doing this for Crossrail. His skills and experience are a natural fit for our project. I am personally thrilled to have him on the team."

Mitchell added: "As an engineer, I am passionate about the critical place well-functioning infrastructure has in driving prosperity and growth. Just like Crossrail, the Thames Tideway Tunnel is essential to the long-term social and economic well-being of the capital and the country. I am honoured and excited to have this opportunity to be in the vanguard of making the project a reality at last."

"Having been closely involved in its establishment at Crossrail, I am particularly looking forward to developing the Tunnelling and Underground Construction Academy at the Thames Tideway Tunnel, ensuring the country has a ready and available pool of engineers capable of meeting the infrastructure challenges the country faces over the next few decades."

One of the UK Government's top 40 national infrastructure projects, the Thames Tideway Tunnel, is required to help tackle the discharges to the River Thames of untreated sewage from London's overstretched, Victorian network. 2mm of rainfall can cause discharge.

substation. The tender process will continue in February with the launch of the prequalification procedure. Interested consortia will have until May this year to apply for prequalification. Over the summer, Femern will select the prequalified consortia and then initiate the bidding rounds for the two contracts.

Thames Tideway appoints new boss

Great Britain Andrew Mitchell, programme director and board member at Crossrail, has quit his job and been appointed as the CEO of the Thames Tideway Tunnel delivery organisation, the company announced last month.

Crossrail is in the process of negotiating Mitchell's leaving date.

Mitchell will report to the Thames Tideway Tunnel's recently appointed chairman,

Danish-German tunnel tender briefing attracts European companies

Denmark-Germany More than 200 companies from across Europe attended a briefing in mid-January on two upcoming tender packages for the EUR 5.5bn (USD 7.5bn) Fehmarnbelt tunnel.

The companies heard presentations given by the management and the technical department of Femern, the company planning the scheme.

According to Femern, nine international consortia are already participating in the tender for the construction of the tunnel itself. The two new contracts cover the 'inner workings' of the Fehmarnbelt tunnel - its electrical and mechanical installations as well as the power supply facilities for the tunnel's operation, including the establishment of a new

substation. The tender process will continue in February with the launch of the prequalification procedure. Interested consortia will have until May this year to apply for prequalification. Over the summer, Femern will select the prequalified consortia and then initiate the bidding rounds for the two contracts.

Steen Lykke, technical director of Femern, said: "Given today's participation of so many highly experienced companies, we anticipate strong competition between the consortia applying for these contracts. The requirements are very tough, but after all, it is a great opportunity to take part in the construction of the longest rail and road tunnel under the sea."

The Danish parliament is set to vote on the construction act for the Fehmarnbelt tunnel



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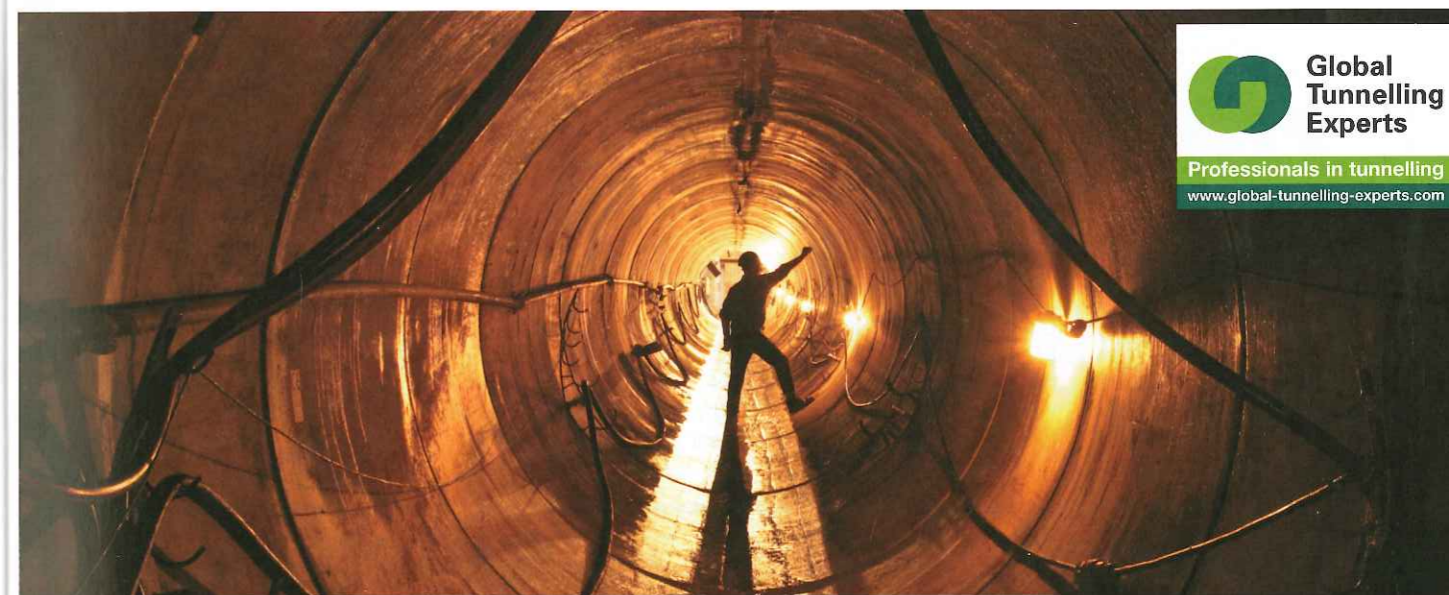
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Tunnel considered to link Mumbai's domestic airport to T2

India The Mumbai airport may become the first in the country to have an underground tunnel for airside vehicular movement, local press reported recently.

Media reported that there is a plan to consider building a tunnel linking the domestic terminal to T2, the new integrated terminal, to improve operational efficiency and reduce delays in departures and baggage delivery.

However, a Mumbai International Airport Ltd spokesperson said the plan had not been finalised.

Fifteen consortia queue up for prequalification on Makkah metro contracts

Saudia Arabia Prequalification is underway for contracts to build two new metro lines totalling 44km in the Saudi Arabian holy city of Makkah (also known as Mecca).

The Mayor of Makkah and chair of the executive committee of the city's public transport company Osama Al-Barr announced on 20 January that 15 national and international consortia have submitted documents to qualify for contracts on the SAR 25.5bn (USD 6.8bn) project.

The first line will be 11km long with seven stations and will be mostly underground. It will run from the Jamrat

region in Mina west via the northern side of the Grand Mosque, King Abdul Aziz Road, and the Haramain high-speed station in Rusaifa to the Makkah-Jeddah Expressway.

The second line will be partially underground and will be 33km long with 15 stations.

It will start in Madinah Road north of Taneem Mosque, then run south along the western side of the Grand Mosque, and via King Abdulaziz Towers, Azizia Street and Taif-Karr Road to Umm Al-Qura University.

Saad Al-Qadi, CEO of Mecca Trains Company, said that civil works will be divided into two packages covering underground and elevated sections.

Construction is expected to begin in the middle of this year and will take around three years to complete.

The two lines are part of a longer-term plan to construct four lines totalling 114km with 62 stations.

Mecca's first line, the 18km Al-Mashaer Al-Mugadassah metro, opened in 2010 and links the pilgrimage sites of Mina, Muzdalifa and Arafat.

Saint Louis contracts awarded to Black & Veatch-led JV

USA The Metropolitan St Louis Sewer District (MSD) has selected a Black & Veatch-led team to manage the construction of more than USD 500M in future

tunnel projects.

The tunnels are part of MSD's long term project to address sewer overflows and basement backups throughout the St Louis area, USA.

The team is responsible for construction management of up to seven different tunnels. The tunnels will range from 9ft (2.7m) in diameter to more than 20ft (6m).

The longest tunnel will be nearly seven miles long (11.2km). All tunnels will be approximately 150 to 250ft (46 to 76m) below the surface. It will take approximately 15 to 20 years to complete all of the tunnels.

Initial construction is expected to begin by early 2015.

Tibetans arrested for disrupting tunnel construction

Tibet Several Tibetans were detained in Derge in early January by Chinese armed forces for disrupting the ongoing construction of an underground tunnel project in the region in December last year, Phayul, which publishes news and views on Tibet and Tibet-in-exile reported recently.

Phayul reported that Chinese armed forces arrived at the Derge monastery and Poenda and detained many Tibetans for their alleged roles in disrupting the building of underground roadways.

In May 2013, Chinese

authorities announced the construction project of the tunnel.

Local Tibetans protested against the construction project.

Geotechnics begin on Brisbane project construction

Hong Kong Geotechnical drilling under the Brisbane River has started as part of planning works for what will be a bus and rail transport construction project in Brisbane, Queensland government announced in mid-January.

Geotechnical drilling investigations began at the Sea Lift 7 barge.

State Premier Campbell Newman said the work is the first step in the project and will involve samples gathered by drilling at least 13 holes up to 60m deep into the river bed.

"The drill is located on a large barge that will move locations over the next few days between Lower River Terrace Park in Kangaroo Point and the City Botanic Gardens," Newman said.

Lawrence Springborg, main roads minister, added: "The tunnel will be carved from the earth by the largest, hard rock TBM ever used in Australia.

"A land-based drilling programme will commence at the end of January at various locations along the proposed alignment to confirm the depth and location of the tunnel and stations."

METRO TO BE BUILT IN TURKMENISTAN

Turkmenistan President Gurbanguly Berdimuhamedov has met with the chairman of the Ukrainian 'Interbudmontazh' Construction Association Vladimir Petruk and raised the issue of the construction of a subway in Ashgabat, a Turkmenistan local television report revealed last month on 4 February.

Addressing the chairman of

Interbudmontazh, the Turkmen president drew attention to the fact that Turkmenistan's capital is developing intensively and required a metro.

In response, the head of the Ukrainian company expressed his sincere gratitude for the trust and assured the Turkmen leader that this issue will be comprehensively studied in detail by leading experts.

The issue of constructing a metro was first raised in 2008 when the Ashgabat municipality invited companies from St. Petersburg.

The Turkmen capital also stands out with allegedly the highest concentration of white marble buildings in the world and a unique fountain complex, obviously making tunnelled solutions all the more attractive.

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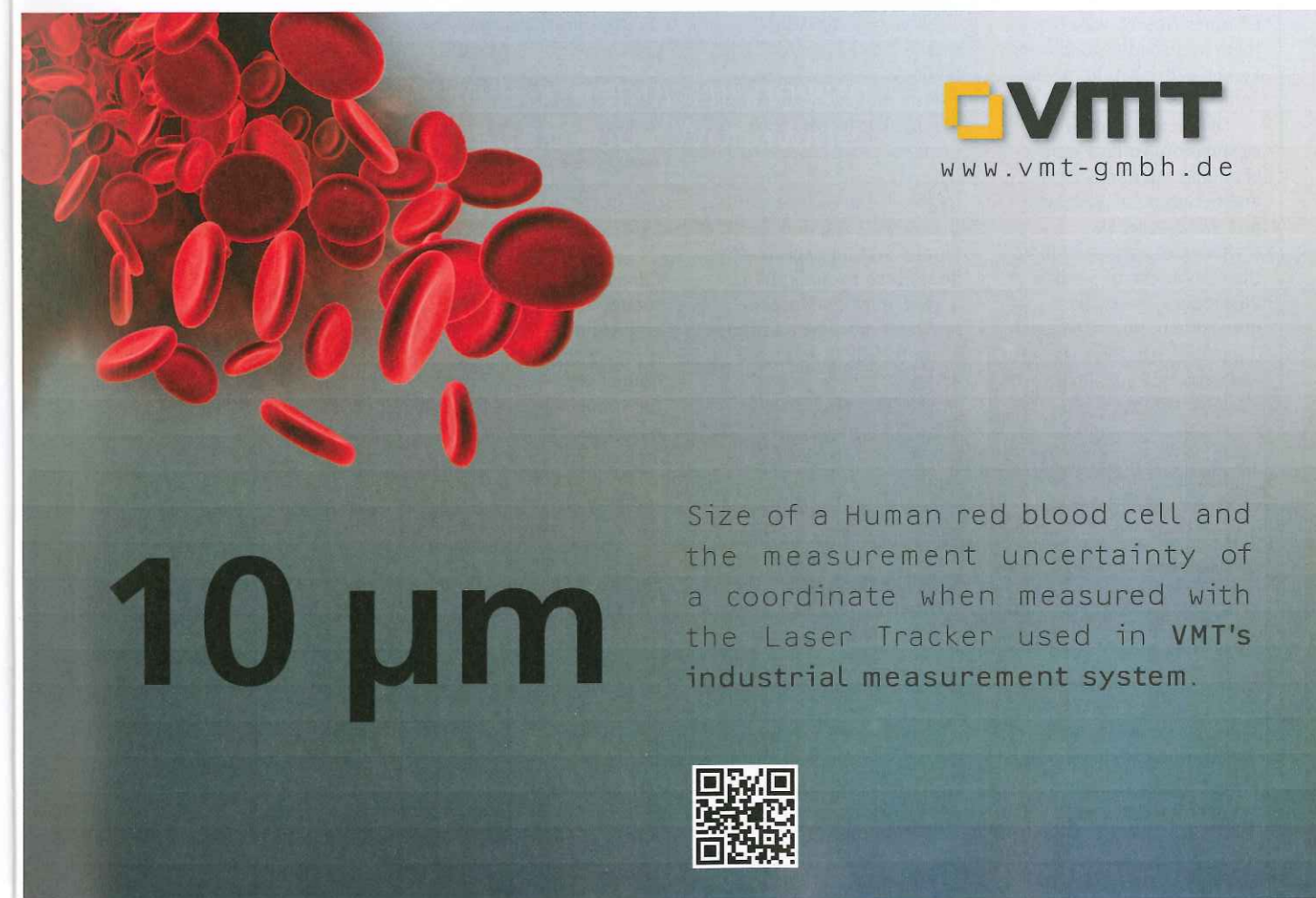
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Size of a Human red blood cell and the measurement uncertainty of a coordinate when measured with the Laser Tracker used in VMT's industrial measurement system.

10 μm



DOHA METRO TUNNEL WORK TO START IN THIRD QUARTER

Qatar The tunnel work for Doha Metro will start in the third quarter of this year, while as construction is progressing on 21 stations, a senior official at Qatar Rail said on 18 February.

"Some 15 TBMs for the metro project are now being manufactured," said Sara al-Muhannadi, business development manager.

She was giving a presentation at the Qatari French Business Club's second monthly meeting.

"The delivery of the first train will be in the third quarter of 2017, followed by the power-on for the first test section in the fourth quarter of the same year," al-Muhannadi said.

Completion of all stations and tunnels will be in the fourth quarter of 2018 and the operations scheduled to start in the fourth quarter of 2019.

Qatar Rail senior programme director Markus Demmler said on the sidelines of the event that some 130 trains were to be brought initially.

"We have awarded four contracts; the fifth one is about to be awarded. We have three elevated sections to be awarded and the system contract (which is under evaluation) will be awarded soon," said Demmler.

He disclosed that there were about nine major construction contracts excluding other consultant contracts.

The project is expected to bring in some 25,000 workers who will undergo "a very rigid safety scheme" with strict supervision.

Part of the award criteria, Demmler stressed, was to select contractors with track records showing they were capable to do the project following the highest safety standards for workers.

Meanwhile, about eight underground stations are being constructed for the Lusail Light Rail Transit and four are 90 per cent finished while tunnelling (cut-and-cover) is already complete. For the remaining stations, architecture and systems will start soon while civil work will continue until 2015.

Channel Tunnel workers suffer carbon monoxide poisoning

Great Britain-France 19 workers suffered carbon monoxide poisoning while working overnight in the Channel Tunnel, with one of them in a serious condition, French officials told media earlier this week.

The incident happened as some 60 workers were changing rail tracks on the line between Calais, France, and Folkestone, UK.

A welder was taken ill in the early hours of Sunday 26 January and carbon monoxide poisoning was later diagnosed. 18 other workers were also taken to local French hospitals.

The 41 other workers went home.

An investigation has been launched into the cause of the incident.

Next procurement stage reached for Thames Tunnel

Great Britain The next phase of procurement for the main construction works contracts for London's 25km long Thames Tideway Tunnel has been reached as the

invitation to tender was sent out for the second works package, Thames Water announced mid-January.

Thames Water sent out the invitation to tender for the East package of work to construct the tunnel on the 14 January 2015, with the final bidders expected to be announced in May next year.

The project has been split geographically into three main construction works contracts, with the invitation to tender for West sent out in December 2013, and the final Central section expected to be released in April 2014.

The three main works packages are worth a total of up to GBP 2.3bn (USD 3.1bn).

The Thames Tideway Tunnel is a major new sewer that will help tackle the problem of overflows from the capital's Victorian sewers and will protect the tidal River Thames from increasing pollution for at least the next 100 years.

Mike Gerrard, Thames Tideway Tunnel managing director, said: "The tender process is now well under way and we are confident that our process will ensure competitive bids that will result in the best value for

our customers.

"We are building for 22nd century London to create a cleaner, healthier River Thames.

The Thames Tideway Tunnel is needed to tackle the tens of millions of tonnes of raw sewage, which discharge into the tidal River Thames every year. The river needs cleaning up and it needs to be cleaned up now".

Confederation Line tunnel makes early milestone on time

Canada Mining of the 2.5km tunnel for the Confederation Line Light Rail Transit project is proceeding on time and on budget with 10 per cent of the tunnel excavation now complete, Transport Canada announced on February 5.

At the West Portal in LeBreton Flats, a roadheader has carved out 228m of tunnel and is currently digging under Queen Street just west of Bay Street.

At the East Portal near Ottawa and Laurier Avenue East, a second roadheader has mined 22m towards Rideau Street.

Mining at the Central Shaft near Queen and Kent streets by the project's third

machine has just begun over the last two weeks with 7m of the gallery that will lead from the construction shaft to the tunnel excavated to date.

"Four years ago, the future and the budget of this project were uncertain, said Ottawa's mayor, Jim Watson. "Today, we have reached a major milestone for tunnel construction.

I'm very pleased with the progress that we've made to date, less than one year after the final contract was signed."

This project is the first stage in Ottawa's future rail network.

The 12.5km electric light rail system replaces existing diesel powered buses, going east-west. The route includes 13 stations and a 2.5km tunnel that will alleviate congestion through the downtown core.

The Confederation Line is a CAD 2.1bn (USD 1.89bn) project that is jointly funded by the Government of Canada, the Province of Ontario and the City of Ottawa.

Rideau Transit Group is responsible for the design, build and maintenance until 2038.



Tel-Aviv Metropolitan Mass Transit System

NTA - Metropolitan Mass Transit System

The Turkish Alignment C&C Tunnel – Announcement of Tender

NTA, an Israeli government owned company, is promoting the implementation of the Red-Line as the first Light Rail Transit Line to be operated in the Tel-Aviv metropolitan area.

Part of the Red Line underground alignment will pass through Neve Zedek, the historical route of the Turkish railway.

The Turkish Alignment C&C Tunnel involves 1,000m of Cut & Cover tunnel work including two underground levels:

- The lower level hosts the underground LRT, commencing at the western end with a descent from the surface to the tunnel portal and includes "Eliphelet" station stop. From the portal, the lower level continues in a western direction ending in the previously constructed Hertzl shaft.
- The upper tunnel level consists of an underground vehicle tunnel from Eliphelet street to Nachalat Binyamin street, including 2 entrance portals (east and west) and ramp to the surface.
- The surface level consists of landscaping throughout the entire alignment of the works, preservation of heritage structures and buildings and remodeling of the existing land use.

NTA intends to issue a Design-Build tender for the civil works of the Turkish Alignment Project at the **End of March 2014**. Tender documents will be published on NTA website at: www.nta.co.il.

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Toronto micro TBM to launch

Canada Toronto Hydro-Electric System Limited announced on 5 February the Dibco TBM has arrived. Additionally, it is already being readied to begin tunnelling north to connect Canada's second underground transformer station to the grid.

The TBM will be on-site at Copeland Station for approximately three months, as it digs 600m to join the existing transmission tunnel beneath the intersection of Lower Simcoe and Front Streets.

Creating the tunnel will facilitate a high voltage connection to the station, which will supply power to Toronto's newest downtown station.

Copeland Station is the first station to be built in downtown Toronto by Toronto Hydro since 1955 and will provide much needed additional capacity to serve current and future load requirements in this high-density, high-growth area of Toronto.

Winnetka Village Council approves MWH engineering contract

USA The Council of the Village of Winnetka, Illinois, voted unanimously to approve a contract with MWH Americas for engineering work on the Willow Road stormwater tunnel, on January 21.

The contract is worth USD 2,023,818 and concerns a major stormwater improvement project, consisting of a new storm sewer beneath Willow Road that would convey water from a roughly 900-acre drainage area on the west side of the Village eastward towards Lake Michigan.

RFQ documents said the proposed project would involve an 8ft diameter storm sewer approximately 7,900ft long. About 3,800ft would be constructed by tunnelling, the remainder by open cut methods. The project includes construction of additional storm sewer connected to the tunnel to provide relief to five drainage basins. The project currently has a cost estimate of USD 34.5M.

According to Winnetka Village engineer and public works director Steven Saunders, MWH's bid included designing and developing the tunnel project all the way through construction.

Woonasquatucket expected to complete this spring

USA Subcontractor, Super Excavators, Inc. (SEI) of Menomonee Falls, Wisconsin, is nearing completion of a 19-month project comprised of 11,976ft of slurry microtunnel work in Providence, Rhode Island.

The Woonasquatucket Interceptor is one part of a series of infrastructure improvements to separate sanitary and storm water flows and eliminate pollution into the Woonasquatucket River, which flows to Narragansett Bay. SEI is using three Akkerman MTBMs, an SL36, SL60 and SL74, which were at times increased to accommodate the six pipe ODS.

All MTBMs are outfitted with mixed ground cutter heads featuring disc cutters and drag bits to excavate the mixed geology.

SEI began work on the project in September 2012 and anticipates completion of 22 total runs in March 2014.

The conduits along the interceptor include some 618-ft (188m), of 30-in (0.76m), RCP; 149-ft (45.4m), of 36-in (0.91m), HOBAS pipe; 4,423-ft (1,348m) of 48-in (1.22m) RCP; 743-ft (226.5m) of 54-in (1.37m) RCP; 2,063-ft (628.8m) of 60-in (1.52m) RCP; and 3,980-ft (1,213m) of 72-in (1.83m) RCP.

SEI's longest drive was achieved in mid-June, representing 1,073-ft of 48-in. ID RCP with the SL60 machine.

The project required careful staging around the shafts amidst narrow streets and traffic constraints imposed by authorities.

Three more KVMRT TBMs to be launched

Malaysia MMC-Gamuda KVMRT, which has seven tunnel boring machines (TBMs) steadily working under Kuala Lumpur, expects the remaining three to be launched by the third quarter of next year under the Underground Works Package.

Its general manager, Stephen Ng, said on 17 December that the machine from Semantan was expected to reach KL Sentral station in the third week of that month.

"A total of 10 TBMs will be used to excavate the twin-bored tunnels for the Sungai Buloh-Kajang Mass Rapid Transit Line (MRT). All the tunnel drives will be at various stages of completion by end-2014," he said.

He said different soil conditions required different types of boring machines.

"The company will use two kinds of TBMs - Earth Pressure Balance and Variable Density Slurry -- to construct the tunnels in Kenny Hill and karstic limestone respectively.

He said the remaining three machines had arrived in Malaysia and would be launched soon from the respective sites.

To date, the company has two TBMs underground from Semantan to KL Sentral, two from Cochrane to Maluri, two from Cochrane to Pasar Rakyat and one from Inai to Bukit Bintang, he said.

Meanwhile, Mass Rapid Transit Corp Sdn Bhd has reported 28.55 per cent overall progress for the elevated package and 41.5 per cent progress for the underground works progress.

"The tunnelling period is approximately 20 months commencing from May 2013. KVMRT project is targeted to be completed by July 2017," it said. The seven underground stations of the MRT Sungai Buloh-Kajang Line are KL Sentral, Pasar Seni, Merdeka, Bukit Bintang, Pasar Rakyat, Cochrane and Maluri.

MRT DELAYED BY LACK OF SKILLED LABOUR

Bangladesh Construction work on the Dhaka Mass Rapid Transit (MRT) 6 has been delayed due to lack of necessary Bangladeshi engineers, said Takao Toda, chief representative of the Japan International Cooperation Agency (JICA).

Toda announced this after a meeting with Finance Minister A.M.A. Muhith at his residence on 23 January. The minister reportedly said the metro rail project was included in the Prime Minister's fast-track development project list for which it would get more speed.

"I will, however, personally give directive to the concerned ministries for speeding up execution of the project," Muhith added.

The construction of 20km of metro rail from north of the Uttara Model Town to the Bangladesh Bank head office is expected to be completed by 2019.

The Japanese government, through JICA, will provide BDT 166bn (USD 2.16bn) of the total project cost of BDT 220bn (USD 2.5bn) as loan at a 0.01 per cent interest rate. The rest will be managed by the Bangladesh government.



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Share tracker

Company	December	January	Change
Aecom (NYSE: ACM)	27.8	30.51	2.71
Atkins (LSE: ATK)	1,348	1,457	109
Balfour Beatty (LSE: BBY)	262	289.7	27.7
BASF Global (XETRA: BAS)	73.94	77.9	3.96
Bekaert (BSE: BEKB)	25.13	25.3	0.17
Bilfinger Berger (DUS: GBF)	79.69	81.71	2.02
Costain Group (LSE: COST)	279	305	26
Ferrovial (MCE: FER)	13.35	14.4	1.05
Hindustan Construction Company (BOM: HCC)	13.55	14.25	0.7
Hochtief (XETRA: HOT)	59.05	63.45	4.4
Leighton Holdings (ASX:LEI)	15.09	16.38	1.29
Morgan Sindall (LSE: MGNS)	753	805	52
Sandvik (STO: SAND)	85	88.9	3.9
Shanghai Tunnel Engineering (SHA: 600820)	9.19	8.19	-1
Strabag (LSE: STR)	20.61	21.23	0.62
URS Corporation (NYSE: URS)	50.74	53.26	2.52
Vinci (EPA: DG)	45.65	48.1	2.45

Prices are taken on the 12th of each month. NYSE is in USD. LSE is in GBP. STO is in SEK. BSE, EPA, MCE, STR and XETRA are in EUR. BOM is in INR. SHA is in CNY. ASX is in AUD.

Balfour Beatty sells Scandinavian rail business

Great Britain UK-based infrastructure group Balfour Beatty has reached an agreement to sell its Scandinavian Rail business including all current operations in Sweden and Denmark to Strukton Rail for a cash consideration of about GBP 4M (USD 6.59M).

With this acquisition, Strukton Rail has strengthened its

Zoomlion opens site in Brazil

Brazil Zoomlion group has opened a production site in Brazil called Zoomlion Cifa Brazil, situated in the city of Indaiatuba, some 90km far from San Paolo. The site is dedicated to the production of concrete machinery, in addition to another site dedicated to other lines of machinery for construction, the company stated.

The area is 22,000sqm with a production capacity of more than 1,200 machines

a year, divided between different production lines including truck mixers from eight to 10cu.m of capacity, dosing and batching plants, concrete pumps and stationary booms.

Arup hires geotechnical expert

USA Engineering and consulting firm, Arup, has recently announced that Sanjeev Malhotra has joined its New York office as an associate principal and geotechnical practice leader.

Malhotra has 22 years of experience in the geotechnical design and construction of infrastructure projects located in the US, Australia, the Middle East and Asia.

Malhotra provides consulting services in foundation and tunnel engineering, soil-structure interaction problems, earthworks, slope stability, landslide mitigation, and seismic studies in a variety of geologic conditions.

"Sanjeev will focus on the continued growth

and development of our geotechnical practice in the New York region," said Gillian Blake, principal and leader of the infrastructure practice team in Arup's New York office.

"We look forward to having his experience and expertise at Arup."

Black & Veatch appoints CIO

USA Black & Veatch has appointed Dan Kieny as chief information officer and VP to lead the company's IT operations, the firm announced last month. In this role, Kieny will oversee the global IT services supporting the company's worldwide business and operations needs.

Kieny has more than 20 years of experience in strategic planning, business process redesign, contract negotiations, staff development and systems integration.

Kieny was previously VP and global innovation director for MWH Global.

Kieny replaces former

Central bank rates

	Rate (%)
AUD	2.50
BRL	10.75
CAD	1.00
CHF	0.25
CNY	6.00
EUR	0.25
GBP	0.50
INR	8.00
JPY	0.10
NZD	2.50
USD	0.25

Rates are taken on the 12th of each month.

CIO Brad Vaughan who retired after 39 years of service. Kieny will be based at the company's Global Headquarters in Overland Park, Kansas.

"Dan has successfully led the implementation of IT in engineering, consulting and construction projects around the world," said Steve Edwards, chairman, president and CEO of Black & Veatch.

"His broad range of knowledge and experience in the field will help enhance the technology has set that our workforce requires to serve our clients' increasingly complex project needs."

Putzmeister launches new low-profile concrete mixer

USA Manufacturer of concrete and material placing equipment Putzmeister, has expanded its low-profile concrete mixers range Mixkret and launched the Mixkret 5 model, offering a concrete mixing and transport capacity of 5m³.

The Mixkret 5 will be presented at Expomin, Santiago de Chile this year. With this new launch, Putzmeister offers a machine equipped with a Caterpillar 6-cylinder Diesel motor, providing great traction force and climbing ability.

Hydrowork reveal new compressed air logging system

Germany HydroWork has announced that it is the first company to develop what it calls a novel mobile automation system for hyperbaric intervention. It uses digital recording technology to log data from compressed air work on TBM drives and caisson work.

A Hydrowork spokesman said, "Precise recording of ingress and egress times are important, and not just for the employer and employee; precise documentation is also essential for the construction developer and the compressed air doctors. The times of ingress and decompression worldwide have hitherto been manually recorded by the lock attendants - and this usually involves a ball point pen and paper, in a damp and dirty atmosphere. The frequent illegible and smudged recordings not only entail time-consuming and multiple checks by personnel departments. They

are also risky, because even the slightest imprecision can damage health and thus lead to high damages claims against the employer."

The system, available from June, can be set up on a TBM within two hours. A live transfer of data enables immediate analysis of the respective worker profile - even via smartphone. All data is archived for a duration of ten years.

Sandvik formalises relationship with technology institute

Sweden Manufacturer Sandvik and KTH, the Swedish Royal Institute of Technology, have signed a strategic partnership agreement to create "an even stronger relationship regarding research activities". Olof Faxander, CEO of Sandvik said, "Research and product development are central to secure a strong position for Sandvik as a company. Formalizing the collaboration with KTH is one way to secure our future talent pool of

researchers and engineers, to build competence in key technologies and to create a dynamic relationship where both partners will benefit from each other."

Peter Gudmundson, Principal of KTH, added: "We have been collaborating with Sandvik for many years. It delights me that we are now formalising the collaboration by becoming strategic partners. It will be beneficial for both of us in an excellent way."

A spokesman added, "Among other things, the objective with the partnership is to carry out joint research activities, promote exchange of resources and discuss future educational direction based on jointly defined needs."

New Bilfinger-led Chinese JV

China The engineering and services group Bilfinger has established a joint venture for facility services together with Siemens, China and Chinese partner Beijing International Technology Cooperation Center (BITCC). The new company will at first assume facility management for real estate at four Siemens' locations in the capital Beijing and in Shanghai.

Bilfinger holds 40 percent of the shares in the joint venture, 25 percent are held by Siemens and 35 percent by BITCC.

"Bilfinger has doubled its capacity in China in the past two years to more than EUR 50M (USD 69M). We also see future growth opportunities there," says Jochen Keysberg, executive at Bilfinger.

Finnish contractor reorganises business units

Finland Lemminkäinen published its new strategy for 2014 - 2018 in October 2013 and announced that it will renew its reporting structure. Until the end of 2013, Lemminkäinen's business was

organised in four business segments: International Operations, Building Construction, Infrastructure Construction and Technical Building Services.

Based on the new strategy, Lemminkäinen will focus on insightful infrastructure solutions and Russia. The renewal will increase the transparency of reporting regarding Scandinavia and Russia.

Project exports, which was previously reported in International Operations figures will be reported under the Finland and the Baltic countries, Infrastructure construction business segment. From the beginning of 2014, Lemminkäinen's business operations will be organised into five business segments: Finland, Building construction; Finland and the Baltic countries Infrastructure construction; Finland, Technical building services; Russia; wider Scandinavia.

Balfour Beatty becomes Stonewall Diversity Champion

Great Britain Balfour Beatty, the international infrastructure group, has become one of the first major construction companies to join Stonewall's Diversity Champions programme.

The programme, run by the gay equality charity, helps employers to develop inclusive workplace cultures for their lesbian, gay and bisexual staff in order to ensure that all staff can perform to their full potential.

Balfour Beatty joins businesses as diverse as The Royal Navy, National Grid, Network Rail and Ernst & Young, amongst over 650 major employer members of the scheme.

Paul Raby, Chief human resources Officer at Balfour Beatty said: "We're proud to join the programme and look forward to developing our work around sexual orientation."

News briefs

SINGAPORE

Singaporean structural steel and specialist engineering contractor Yongnam Holdings reported a reduced net profit of SGD 5.5M (USD on the back of a revenue increase to SGD 361.6M (USD 284.93M) for the year ending 31 December 2013. Commenting on the Group's full year performance, Seow Soon Yong, Chief Executive Officer of Yongnam, said, "Yongnam had achieved outstanding performance for a number of years when the Group was consecutively involved in a number of iconic projects in Singapore that delivered very attractive higher margins. While our current projects do not enjoy such high margins, the Group continues to pursue a number of large infrastructural projects in Singapore and the region."

GREAT BRITAIN

Costain's Design & Building Information Modelling (BIM) Manager, David Owens, has been invited to join the committee of the BIM 4 Infrastructure (UK) advice group. "BIM4UK evolved out of a Special Interest Group within the Association of Geographic Information and BIM4Rail," explained Owens. "It now includes representatives of the main professional institutions." It aims to move knowledge of BIM both vertically, up and down the supply chain, as well as horizontally across different industry sectors.



Center: Martin Herrenknecht, his right: Gerhard Schröder, his left: Qatar Transport Minister Jassim Saif Ahmed

HERRENKNECHT DELIVERS

A delegation of Qatar Rail representatives visited Schwanau, Germany on Monday. The visit to the Herrenknecht factories was to inspect the first of the 15 TBMs being manufactured the German machinery giant for the Doha Metro project.

The machines have a diameter of 7m and a cutting wheel drive of 1,280kW, with a thrust force of 43,400kN. The geology will be limestone.

The visitors included Qatar transport minister Jassim Saif Ahmed Al Sulaiti, who was met by Martin Herrenknecht and former German ch Ahmedancellor Gerhard Schröder.

The Qatari minister said, "Qatar holds its hopes and aspirations for the future in accordance with the Qatar National Vision 2030. One of the most important elements in fulfilling this vision is the infrastructure of the country itself. As such, we have allocated tremendous resources and a generous budget for upgrading Qatar's infrastructure, to which Qatar Rail's Doha Metro project is also included."

The EPB shields inspected were ordered by the joint venture contractor Qatari Diar Vinci Construction Grands Projets/GS Engineering /Al Darwish. The joint venture is responsible for the construction of the Red Line South, and will utilise five of the EPBMs for 34.7km of tunnel length.

The Red Line North will use four of the EPBMs over 22.7km of tunnel, and will be carried out by a joint venture of Salini Impregilo, SK Engineering and Construction, Galfar Al Misnad Engineering and Contracting.

The Red Line will handle the bulk of the national transport and connect the most important stadiums of the football World Cup in 2022.

The 32.9km Green Line, also part of the first phase of Doha Metro, will take the remaining six machines, and will be executed by a joint venture of PORR, Saudi Binladin Group, HBK, and Hamad Bin Khalid Contracting.

Qatar Rail expects all the 15 machines to be shipped to Qatar within the year. This phase will realise 90km of excavation work by 2019

LETTER: TBM PROGNOSIS METHODS

Dear Sir,

Regarding the *Tunnels and Tunnelling* December 2013 article 'Forward March' by Salehi and Shahandeh.

I imagine this TBM article title was probably not chosen by the authors. As a result the writer missed it until catching up on post-travels reading today. As the writer's QTBM method was included in the study, interest in making some comments needs to be excused.

With the benefit of English as first language we should be careful to criticize those who have inevitable difficulties. Nevertheless, there are so many illogical statements and a clear lack of understanding in this potentially interesting comparison of TBM prognosis methods, that I hope some opinions will be allowed. The 'signature' figure on the first page, with arrows going 'every which way' has some relevance.

It seems that this research on comparison of TBM prognosis methods, in relation to the 16km long Karaj-Tehran water supply tunnel, was undertaken with Bieniawski as an advisor. It is a pity that he was not asked to review the manuscript, since his RMR/RME/ARA methods were clearly the focus of interest. There is sufficient confused opinion (not only poor language), to suggest he did not see this before it went into print.

Consider the following on page 36: "In the Barton method, the factors which are effective in operation and affected

by geological conditions and manpower operations, have been ignored. Geological conditions are the only parameters that have been included except for joint filling. This defect is seen in an earlier version of the rock quality index (Q). Besides the immediately contrary statements, the 'joint filling' comment is presumably due to a Table 3 author's 'scoring' of only 2 points for QTBM, yet an inexplicable 0 points for RME. Again in the Conclusions the 'joint filling factor' supposedly considered insufficiently (in QTBM) is criticized. The Ja rating range of 0.75 to 20 (and a faulted rock SRF potentially multiplying this by 2.5, 5 or even 10) is presumably overlooked by the authors.

In the tunnel logging, where RMR for eight of the nine geotechnical zones is given some presumably sensible, varying representative values of 67, 55, 73, 57, 80, 62, 57, 52, the Q-value by comparison is given a somewhat disinterested-looking or not understanding 20-30 (for four consecutive zones, and 10-20 (for the next four consecutive zones). This does not bode well for a viable comparison of prognosis methods.

In Figure 3 on page 36, the authors show predicted penetration rates for the different zones in m/hr. Three prognosis models are compared. Using QTBM, CSM and NTNU methods, the authors present PR as high as 33 m/hr (!) in the case of CSM, and up to 25 m/hr (!) in the case of QTBM. The NTNU prediction of the authors is almost a straight line of 2.5 to

3.0 m/hr – much more believable but also suggesting some errors of understanding. Are the authors aware that the operator reduces thrust if PR becomes too high, to avoid overloading the conveyor? But where does 25 m/hr come from when Q is supposedly '10 to 20'? What remarkable high thrust was assumed, or what is the source of their lack of understanding? No PR is given for the RME method, as apparently (and remarkably) PR is not 'dealt with'.

On page 36 the authors assume that: 'QTBM method, involves the CLI index as the only parameter reflecting machine characteristics'. Is not cutter thrust – as a result of TBM operation, not considered (at least an applied) 'machine characteristic'? Finally, in the Conclusions, the authors suggest: 'WithQ and repeated use of it in both mining and civil projects, it is possible to assess accurately the geological factors'. So during the course of the article the authors have stated first that the QTBM method ignores geological factors, then geological conditions are included (but not joint filling apparently), and finally the authors think geological factors can be assessed accurately using Q. However they think 'the QTBM model knows the self support of the tunnel (sic) as well as excavation capability'. 'In the QTBM model, utilization of machine at the any (sic) is dependent on...'

Dr. Nick Barton
Nick Barton & Associates

Three more lines planned for Dubai metro

UAE Plans to extend sections of Dubai Metro are on track with the designs of the expansion on three ends of the network currently being worked out, a senior Roads and Transport Authority (RTA) official said in Dubai on 4 February.

The plans will also include building 21 more stations on the entire network.

"The Green line will extend by 20.6km, 12km of which will be elevated and 8.6km will be underground," said Abullah Yousef Al Ali, acting CEO of RTA's Rail Agency. "The extended section will be supported by

11 new stations in addition to current 20."

Al Ali revealed the details of the expansion plan on the sidelines of Middle East Rail conference at the Dubai Convention Centre.

"The designs and details of the expansion project are currently being worked out and work on the project will begin soon," he said.

"All the extensions will be ready in time for Expo 2020."

The Red Line is currently served by 29 stations; after the extension 12 more stations will be built.

By 2020, the total length of Dubai Metro will be about 110km and the Red Line will be extended by 3.5km from Rashidiya to Mirdiff, while

another 15km will be added from Jebel Ali to the Expo 2020 site near Al Maktoum International Airport.

Al Ali said the routes and the stations were planned following extensive studies that looked into aspects like developments around the area and the proximity of the proposed locations to the residential and commercial neighbourhoods.

RTA is targeting an increase of one per cent every year in public transport share of road users over the next two decades.

Dubai Metro currently carries 13,000 passengers per hour per day and has the peak capacity to carry 26,000 passengers per hour per day.

At the conference Al Ali revealed that the Dubai Metro network currently operates 56 trains and 23 trains are in spare. He added that the system has the capacity to run a train every 90 seconds at its peak.

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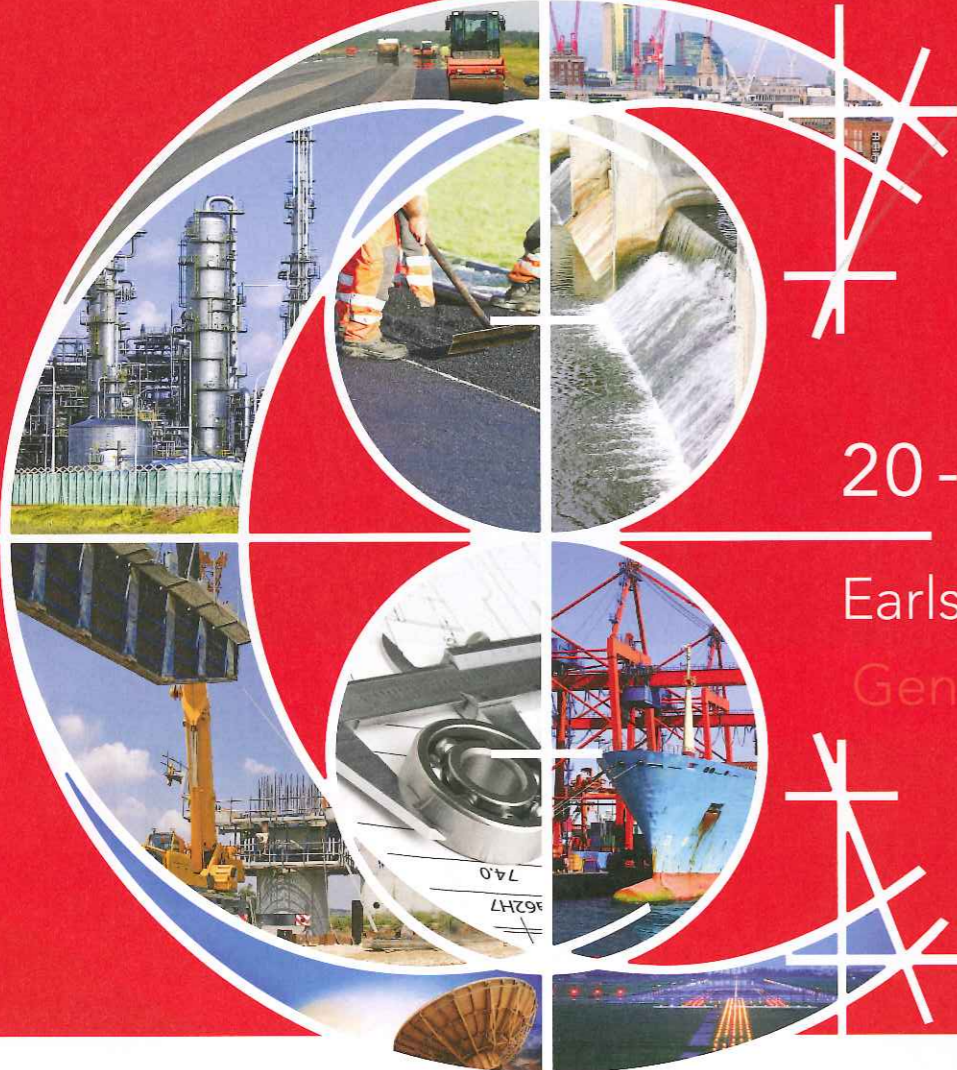
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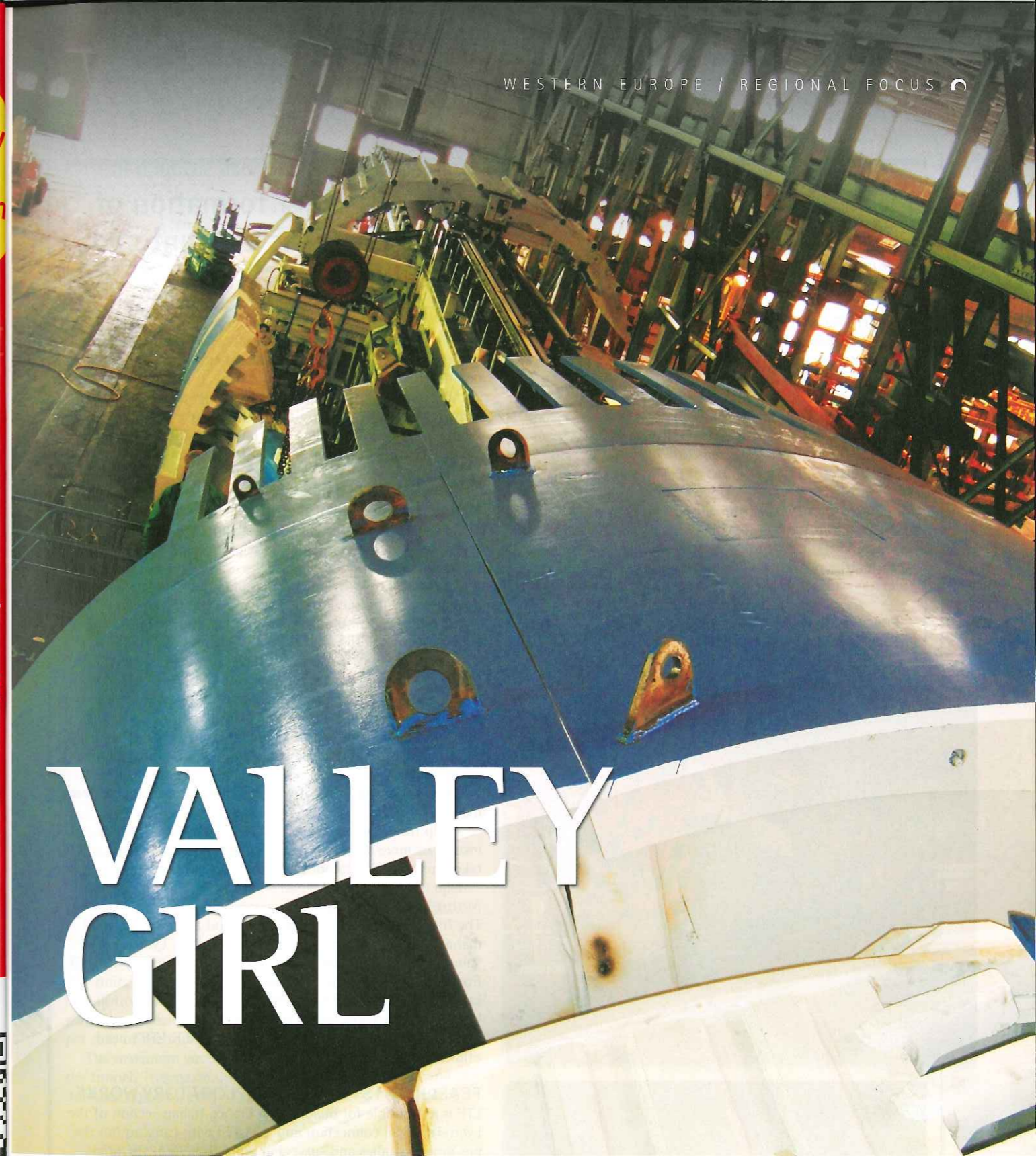
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The Lyon Turin high speed rail connection calls for a base tunnel under Mount Ambin. Personnel from site manager Systra, and client Lyon Turin Ferroviare discuss plans for La Maddalena exploratory tunnel, the organisational structure of the stretches of line, and problems that have dogged the project since before site handover

THE FUTURE high-speed rail 'Mediterranean Corridor' will be a line that will run for a total length of 3,000km across several EU nations. The line is listed among the 10 top priority projects of the great Trans-European Network (TEN) for the period 2014-2020. The corridor starts from Algeciras in Spain and runs to Budapest in Hungary. This line includes the Spanish

Authors

Demetrio Morabito
Demetrio is a managing director with Systra managing the activities of both the subsidiary and the branch of the engineering group Systra in Italy and in the Adriatic countries

Giampiero Pavoni
Systra's project manager was also the designer of major infrastructure projects which have included the Livorno and Civitavecchia, motorways

Antonio Raschilla
Antonio works has worked as a technical- economical worldwide bid manager. Since April 2013 he works for Systra as a site manager

M. Bufalini
Executive director with client LTF

A. Farinetti
Technical manager with LTF

P. Elia
Site manager with LTF



"Traditional tunnelling was stopped in August 2013 when a formation of mica schist was encountered in the drive."

Algeciras-Madrid-Tarragona and Seville-Valencia-Tarragona stretches, before crossing Barcelona, where there is also a rail-port-interconnection.

After this it runs through France from Perpignan, and through the Lyon-Turin route into Italy, where it should then join up with the Milan-Venice route and Trieste before connecting with Ljubljana in Slovenia and then Budapest.

THE LYON - TURIN TRACK

The first Italian stretch of the Mediterranean Corridor is the Turin-Lyon connection. The new line project will constitute a total 256km of railway (for both freight and passenger traffic) between France and Italy.

The job includes two new high-speed stations in Saint Jean de Maurienne (on the French side) and Susa (the Italian side), which will be linked through a twin tube base tunnel, running 57km underneath the Alps.

Once completed the tunnel will be one of the longest underground connections in the world. Considering the permanent increase of the exchanges in Europe and in particular through the Alpine arc, this new railway will allow the transfer of a large portion of freight and passengers onto the rail network, substantially reducing pollution in the Alpine environment.

Moreover in the future it will be easier to travel around the main EU cities.

A trip from Turin to Lyon will take around 100 minutes instead of more than four hours, and from Milan to Paris will take four hours instead of the current seven hours.

Management divisions

The future connection between Turin and Lyon will be managed by Réseau Ferré de France (RFF) from Lyon up to Saint Jean de Maurienne, and by Rete Italiana Ferroviaria (RFI) from Susa/Bussoleno up to Turin. The cross-border section between Saint Jean de Maurienne and Susa/Bussoleno will be managed by Lyon Turin Ferroviare (LTF) which is a private company owned in equal parts by RFI and RFF. LTF's head office is in Chambéry, France.

FEASIBILITY STUDY AND EXPLORATORY WORKS

LTF is responsible for building the Franco Italian section of the Lyon-Turin rail connection and is tasked with carrying out the pre-project studies and surveys in order to present the final details of the civil engineering work required, their location, cost and conditions for construction to the French and Italian governments.

To investigate the geological structure of the future base tunnel between Saint Jean de Maurienne and Susa, client LTF, during last 12 years, has commissioned four sets of site investigation along the line. Indeed on the French side, preliminary works for the construction of the base tunnel are now complete, with the excavation of three access tunnels in the Maurienne Valley:

- The 4,000m access gallery of Villarodin-Bourget/Modane, ended in November 2007

Key parties

- LTF (Lion Turin Ferroviare): the Client
- GEODATA-SYSTRAS.A.: Site Supervision
- Joint Venture CMC-Strabag-Bentini-Cogeis-Geotecna: Contractor Tunnel Execution
- Joint Venture BORIO-IG-PM-Eurosol-Franco-Euroverde: Contractor Spoil Storage

- The 2,480m of La Praz, ended in January 2009
- The 2,400m of Saint Martin La Porte, ended in July 2010.

All these access galleries allowed a better understanding of the geological structures, to better evaluate the technical difficulties and thus the construction methods and costs.

In the Italian territory, the exploratory tunnel of La Maddalena is under progress. The data records will allow an assessment of the most suitable construction methodology, technical and safety aspects and cost valuation for the future base tunnel. During the construction phases, they will be used to gain entry to the various underground works.

When in service, the access tunnel will provide ventilation, access for maintenance teams and, if necessary, emergency crews.

LA MADDALENA EXPLORATORY TUNNEL

The works for the Italian exploratory tunnel started in April 2012 and will terminate in the spring of 2017. The job site is near Chiomonte, a small town in the Clarea river valley.

The total length of the tunnel will be 5,765m plus 1,776m as an optional extra length, which will, if opted for, be approved by the client this year.

The first 198m were bored by the 'traditional method' (NATM) using of drillers, as at this stage the use of the explosives had been forbidden for security reasons (further details below).

Traditional tunnelling was stopped in August 2013 when a formation of mica schist was encountered.

The rest of the length will be bored by the use of an open mode TBM supplied by Robbins, called GEA, meaning 'Earth' in Italian.

TRACK AND GEOLOGY

The tunnel will cross through different geological scenario belong to Ambin formation, constituted by gneiss with presence of quartz and mica schist which represent more of 95 per cent of the total length.

The maximum cover will reach 2,000m near to the end of the tunnel. The maximum slope is 1.10 per cent uphill and 3.94 per cent downhill. The track presents two bends with a

2,000
Metres is the maximum cover of the tunnel

1,000
Metre-radius curves on the alignment in two places

radius larger than 1,000m. The final project was envisioned by LTF (with the help of preliminary investigation). During tunnel construction geotechnical investigation from the TBM will be carried out by JV Contractors led by CMC Ravenna (Italy).

NO TAV MOVEMENT AND TBM TRANSPORT

NO TAV ("No to the High-Speed Train") is a movement based in the Susa Valley that opposes the construction of the new high-speed railway line between Turin and Lyon.

The entire area of the jobsite has been transformed into an area of 'strategic interest for the country', and is regularly patrolled by hundreds of policemen and soldiers. These measures began in June 2011.

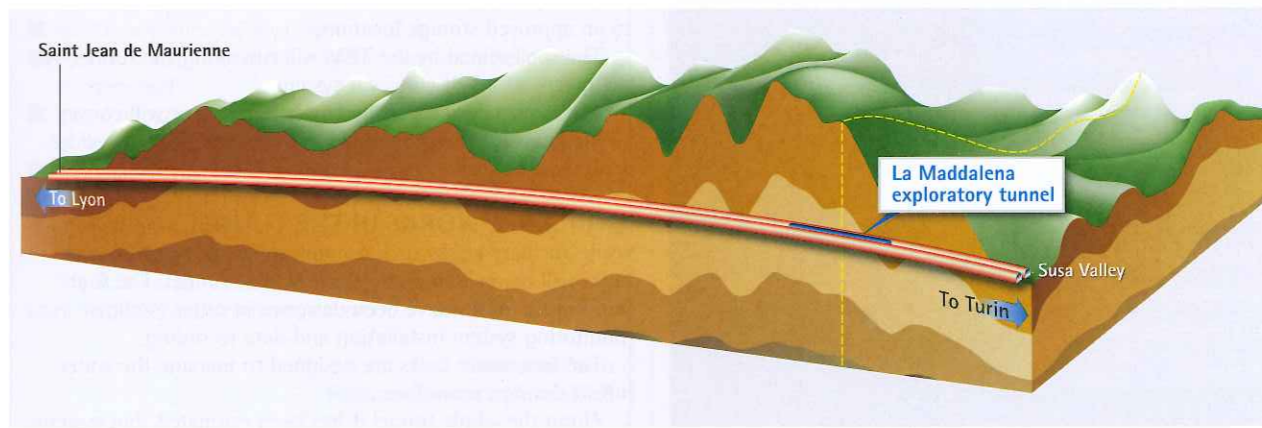
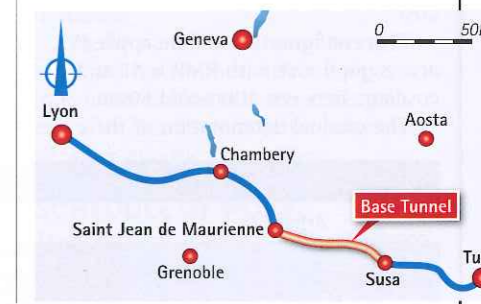
Due to the opposition movement's activities against the job, it was necessary to precisely organise and to manage all TBM and equipment transport from the supplier to the jobsite. Thanks to detailed planning relating to the real needs of the contractor's schedule and delivery requirements, and the cooperation between security force, client and contractor, it was possible to manage the supply of the equipment into the jobsite without public nuisance, or inconvenience to work or schedule.

The whole TBM, including back up, was transported by means of 10

Opposite: The Robbins TBM on site and in the factory

Right: Key cities along the rail line

Below: The exploratory tunnel



exceptional and 90 ordinary transports, during the month of August 2013.

GEA

In order to match the geological investigation needs, and the time schedule required, an open mode TBM was chosen.

The Robbins Main Beam TBM, called GEA, allows quick access directly behind the cutterhead for the installation of rock support (rock bolts, steel mesh, ring beams, and shotcrete) by means of two specifically designed working areas, L1 and L2.

The first one, the L1, is located at 6m from the excavation face. The second one, L2, at work some 41m behind the face.

From L1 workers will carry out 36m-long probe drilling operations to investigate the rock before boring it. Taking into account the 7m of overlap between two consecutive probes, no section of tunnel will be excavated before thoroughly understanding its features.

All data will be recorded and filed to build an accurate geological picture.

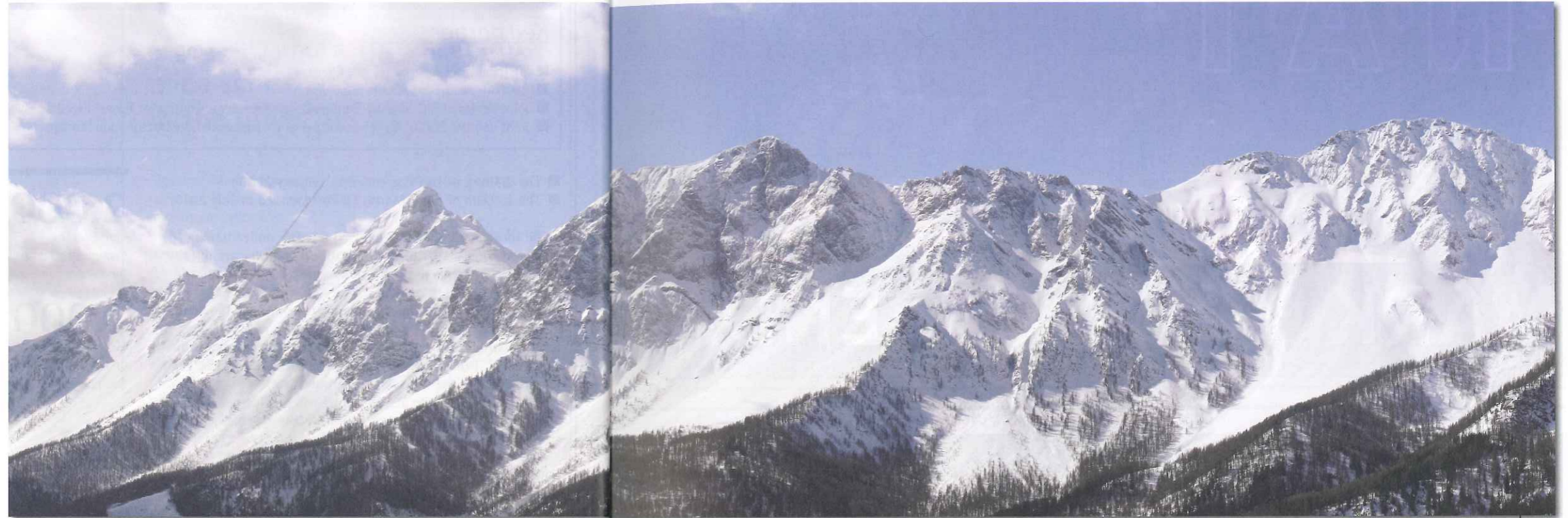
SECTIONS

During the excavation, different support sections depending on the rock quality encountered will be installed.

The tunnel as designed takes 12 different section types into consideration, from F1 up to F5c. The first, F1 section, adopts Swellex bolts long 3m installed from the L1 working area.

This configuration will be applied across good rock with RMR > 81 and coverage between 100m and 600m.

The gradual deterioration of the



Above: New rail lines and tunnels through the Alps significantly reduce travel time in Europe.

rock will require stronger support systems, realised as a greater number of bolts, steel mesh, and increased water drainage. If rock presents fault zones, high coverage, and an RMR lower than 40, the final classification; F5c will be the required application.

A proper consolidation around the excavation profile should be carried out from L1, then from L2 TBM working area steel reinforcement panels and sprayed concrete will be installed.

SPOIL MANAGEMENT

During the first phase of NATM excavation, dumpers were employed to load and move excavated material. At the portal area, three 'pools' to house 5,000 cubic metres of material each were built.

When a pool is full (or when the rock encountered during the excavation changes geological characteristics) an authorised laboratory carries out analysis required under Italian Legal Decree 152/86. Depending on the results, the material will be stored in a proper area inside the jobsite by a different contractor.

If the soil extracted and analysed does not present the right features to be stored onsite, it will be classified and transported to an approved storage location.

The spoil mined by the TBM will run along the tunnel by the means of a belt conveyor system.

At the portal area a secondary belt conveyor will convey all materials in correspondence to the pools where it will be analysed.

ANCILLARY WORKS IN THE TUNNEL

Some ancillary works such as monitoring rooms and water tanks will be realised along the 7.5km of tunnel. The four monitoring rooms have been designed in order to allow monitoring system installation and data recording.

The four water tanks are designed to manage the water inflow during excavation.

Along the whole tunnel it has been estimated that systems

Manufacturer notes

The basic purpose of the project is to explore the geology and identify any related problems within Ambin Mountain. Geology is generally Schist, and includes calcite schist, mica schist, and some gneiss.

There will be high cover, and in some of these areas there are risks of rock bursting and other pressurised rock events. An advance of 12m/day should be feasible, and depending on ground conditions, event more.

Features of the 6.3m diameter, open gripper TBM include the following:

- Cutterhead suitable for over-excavation in case of tunnel deformation. This machine has the ability to overbore by 200mm by keeping the invert in the same place, enabling the machine to continue to bore even in squeezing ground conditions.
- Rock bolts immediately behind the cutterhead
- Work platform (nearest as possible to CHD) for radial rock bolting and possibility of shotcrete
- Ring beams immediately behind the CHD
- Possibility to probe for the length of the tunnel (recovering of cores, too)
- Invert thrust means that this machine will have the ability to thrust off invert segments when the conditions are poor.
- Automatic data recording system
- Methane /gas monitoring system including Radon monitoring system

The Robbins team was involved in machine assembly, but after that, the JV will carry out operation of the TBM.

Piermario Porro
Robbins Europe, Italian office

will need to manage 285 litres/sec. Water will be divided and collected in four different types: cold potable, cold not potable, hot dirty and hot clean.

At the tunnel's lowest point (pk 4+090) two water tanks will be built able to manage approximately 300 litres/sec. Two other tanks will be installed towards the tunnel exit (pk 2+805), which will store the water and will pump it outside.

At the portal area a water treatment plant will receive four different pipes (one for each kind of water collected) and after cleaning processes, will convey all water into the Clarea River.

SCHEDULE OF WORKS

Traditional excavation of 198 mt started in January 2013 and terminated in July 2013.

TBM assembly started in the middle of August 2013. At this stage the working schedule of La Maddalena jobsite is nine months in advance compared to contractual schedule.

The average production prediction for the TBM is 12m per day, in order to finish the first 5,765m at the latest in 18 months and the entire (including optional extra length) drive of 7,541m in less than 24 months. TBM dismantling will then last four months.

In the final project visualisation, it is expected that La Maddalena could serve as a safety access tunnel for the main tunnel.

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Attribute	Value
Type/model	Open Robbins
Total installed power	7x315kW electric
Excavation diameter	6,300mm
Cutterhead rotation speed	0-9.3 round/min
Cutterhead maximum thrust	13,667kN
Number of cutters	43 (17-inch)
Max load/cutter	311.5kN
TBM primary voltage	15kV, 50Hz
Belt conveyor width	914.4mm
TBM length (exc. backup)	25m
TBM length (inc. backup)	250m
TBM weight	250t

Source: Authors

2 N o A 1 T 4



The Croix Rouse Tunnel rehabilitation and expansion project in Lyon, France had a number of technical considerations to overcome. This article is drawn from material provided by Vinci

A CROIX-ROUSSE (the Red Cross) hill in Lyon, France was the centre of the city's 19th century silk industry. Although there were over 7,000 mechanised looms in the city, and following 1815 the industry enjoyed an average growth of four per cent for 65 years, it was more of a fine craft capital than an bustling industrial centre, with the 7,000 mechanised looms representing around 20 per cent of the total in 1875.

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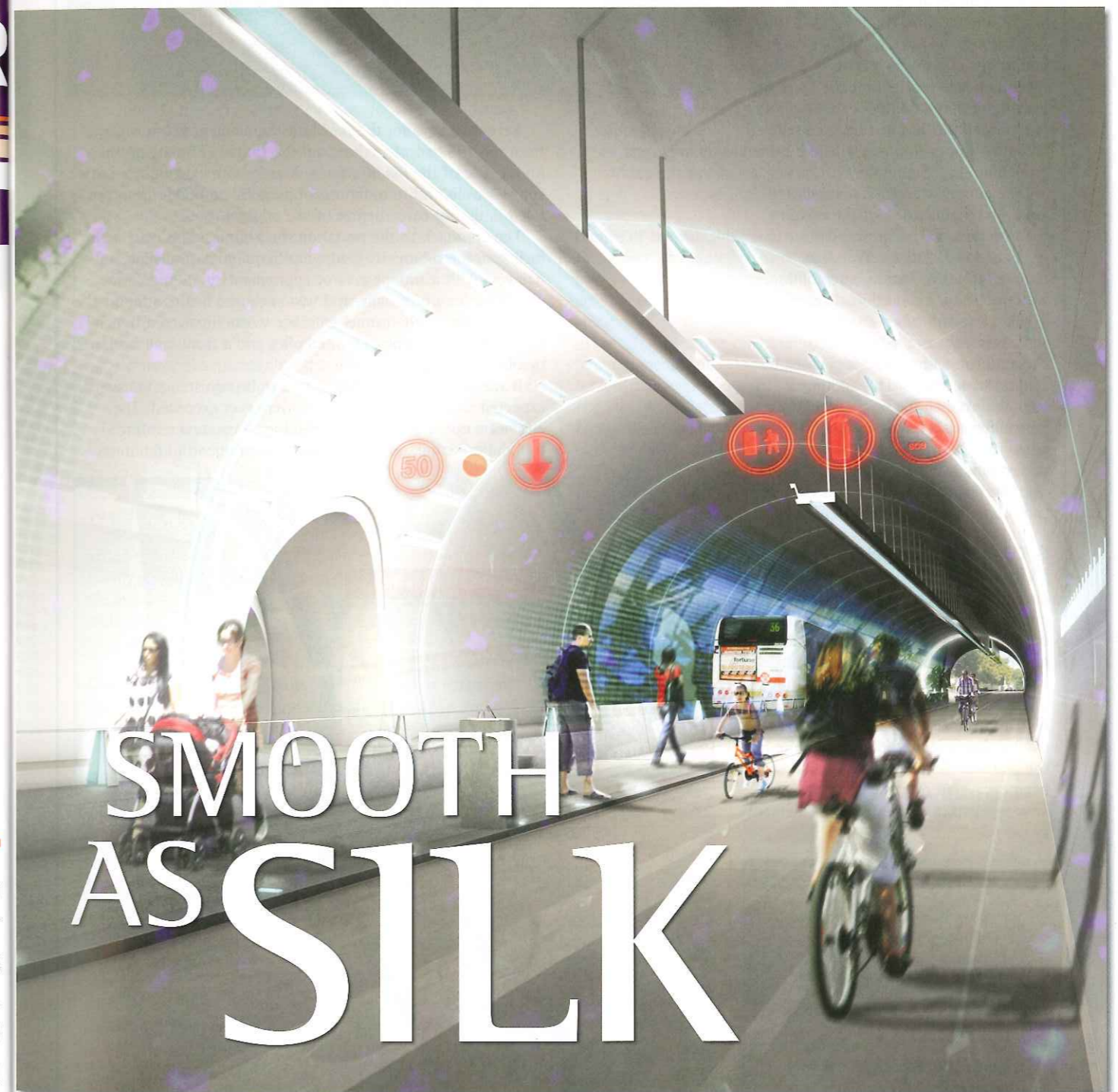
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Still, not all was well. Social issues marred the period. Three revolts by the Canuts (silk workers) took place in 1831, 1834 and 1848 against poor treatment and worse salaries. The 1831 revolt was in response to a refusal by the manufacturers to set a minimum price for silk and the 1834 was due to owners cracking down on increasing worker salaries while the industry boomed. The 1848 insurrection was much the same as the second, but took place in the European 'Year of Revolutions' and is less of an isolated issue.

In the modern day, the hill is the site of a road tunnel built in 1952, the Croix-Rousse Tunnel, which like the conditions of workers a century before, recently needed to be brought up to an acceptable standard. Work that began in November 2012 has just been completed as Tunnels goes to press, with the tunnel reopening on 2 September 2013.

The current standards necessitated work on rehabilitation of the existing road tunnel and its five ventilation ducts and installations. Work has required asbestos removal, demolition, waterproofing. In addition, a second 1.76km ('north') tube was required to serve primarily as a safety gallery for the road tunnel has been excavated by traditional methods. This additional tunnel, linked to the original by 11 connecting galleries, is designed to allow for 'green-mode' transport, i.e. pedestrians, cyclists and buses. There is also the future possibility for a two-way tram to replace the buses.

SITUATION FOR THE NEW TUBE

La Croix-Rousse forms the eastern end of the Lyonnais Plateau. Bedrock consists of granite and gneiss. Miocene and Pliocene tertiary sedimentary rocks cover almost all of this, with a mantle of quaternary soil above. The hill is a plateau, flat with steep inclines. Tunnel overburden is around 60m (throughout the plateau). Galleries into the hill have been excavated over the centuries and have resulted in some surface settlement in the past.

Timelapse

The YouTube channel 'grandlyontv' hosts a timelapse video of construction works, showing the development of the nine-month project in 90 seconds.

Just search for: "Tunnel de la Croix Rouse, le chantier : 9 mois en 90 secondes" to view it



Below: Alignment of the tunnel in the city centre

Recent surveys for the new bore supplemented knowledge from the 1952 construction, and the tunnel entrance on the Rhone side of the hill interfaces directly with existing masonry support walls and foundations of demolished buildings, often filled in during construction of the original tube.

The approach to the portal on the Rhone side is on a major incline in the urban city centre and required a 30m-high soil nail wall with a surface area of approximately 550m². Some 3km total length of nails, and two anchored beams support the wall. The rest of the tunnel entrance works involved a trench between two curtains of jointed piles and a front wall anchored by fiberglass nails.

It was key that the entrance had to be adjustable in case expected displacement thresholds were ever exceeded. The engineers opted for passive anchoring to create a reinforced foundation, combined with active anchoring with additional



Addressing vibration

The first problem to be addressed with the use of explosives was that of defining the acceptable threshold limits for the vibrations for the buildings and the existing tunnel kept in operation. These threshold limits also had to allow the extraction of a very hard rock, in a manner consistent with the requirements of the works schedule. From this perspective, the CETU has been associated with the Project from the early phase of the detailed design. Determining the threshold limits for the tunnel in operation was extremely delicate. The structural resistance of the structure (civil engineering and plant equipment) re- mained relatively difficult to assess, despite the inspections undertaken.

Two approaches were carried out

Firstly, an empirical approach qualifying the threshold limits chosen for other structures in relatively similar conditions: Somport Tunnel, the Lioran tunnels, and a tunnel in Monaco, etc. Structures in the urban environment and/or very deteriorated and/or constructed with a slab acting as a ventilation duct. For this approach, CETU's vast experience was valuable.

Secondly, a computational approach, conducted by Spie Batignolles TPCI and SETEC engineering department, involving the double modelling of the South tunnel. On the one hand, a calculation of the static strength to determine the maximum vertical displacement tolerated by the slab ventilation. On the other hand, a modal analysis, undertaken to model the forces on the structure from the vibrations of various frequencies and different amplitudes. In particular, an analysis of the dynamic behaviour of the slab due to forces resulting from the displacement of supports corresponding to the test blasts carried out in 2008 (test campaign carried out by IDETEC, at the request of the Contracting Owner prior to awarding the Contract).

From this approach, the slab was assessed to be much weaker from the vertical displacement induced by the blasts and purely dynamic loads. As for the body of the structure, the analysis showed that it was able to withstand particle velocities between 80 and 100 mm/s, for frequencies above 30 Hz.

However, these 2 approaches did not allow the actual reaction of the internal structures in place to be known for sure, mainly due to a lack of awareness of their exact condition and the impossibility to carry out a more detailed survey (asbestos materials, destructive testing impossible and heterogeneity of floor slabs made from masonry filler units).

Choice of the threshold limits for the tunnel in operation

The sensitivity of results to the slab support conditions and other modelling parameters has led to the preference for a vertical displacement threshold for the slab and not a threshold for

particle velocity. For the body of the structure, threshold limits "for the rock" (input force) have been defined according to the frequency range, preferably at threshold limits corresponding to the re- sponse of the structure, which is variable from one point to another of the structure. Based on these considerations, the following values were finally chosen.

Vibration measured as close to the rock as possible:

- working threshold limits (objective of the blast pattern)
 - F < 30 Hz: 15 mm/s
 - for all frequencies: 30 mm/s
- maximum threshold limits:
 - F < 30 Hz: 25 mm/s
 - for all frequencies: 50 mm/s

Ventilation slab:

- Working threshold limits (objective of the blast pattern) for all frequencies:
 - vertical displacement of 5mm
- Maximum thresholds limits:
 - all frequencies: vertical displacement of 8 mm

Choice of the threshold limits for buildings at the surface

This aspect was addressed by researching recommenda- texts providing strong guarantees. AFTES (Association Française des Tunnels et de l'Espace Souterrain) advocates respecting vibration levels of 10 mm/s, without specifying the frequencies (GT No. 3). This choice can be penalising for high frequencies (not detrimental) and, on the contrary, not conservative enough for low frequencies (< 30 Hz). The choice for the most suitable text was the ministerial circular of 23 July 1986. The document proposes a range of threshold limits depending on the condition of the buildings and the frequencies of the applied vibrations

For the lowest frequencies and the most sensitive structures, the threshold limits can be dropped to 4 mm/s. The classification of the buildings is based on objective criteria, which are provided by the circular. In the context of the pre-construction survey, the experts appointed by the High Court had the task of classifying the buildings according to the categories described in the circular.

But in fact, given the doubts and unknowns about the foundations, virtually all the buildings were considered as being part of the "very sensitive buildings" category, i.e. threshold values between 4 and 9 mm/s, depending on the frequency.

Francois Lopez, SPIE Batignolles
Florent Martin, SPIE Batignolles
Thierry Panigoni, CETU

tensioning capabilities to control displacement of the nailed foundation and the structure.

THE SINS OF THE FATHER

The engineers reported that there was no indication why the earlier tube was built 1,753m-long with a flat profile, considering the drainage difficulties. This was unchanged during renovation, and due to disabled access, connections between the tunnels could have no more than a four per cent incline. While the new tube incline never exceeded 0.12 per cent with the highest point in the middle. A difference of only 1m between the ends.

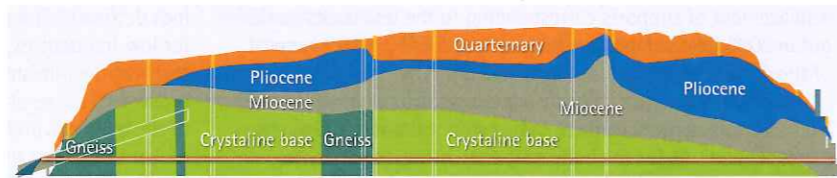
These complications, as well as the difficulty of excavating trenches in granite (and road closure minimisation), made

Right: Situation of the tunnel entrance in the side of the plateau



drainage challenging.

In a paper (Clayton, Soler, Voiron, 2011) the authors look to the design



Above: Geological profile along the alignment

means that the depth of the drainage networks in the Southern tunnel does not have to exceed 2.2m below the finished roadway. Consequently, no drainage network emerges from the renovated Southern tube, which has also solved the problem of crossing the future subway located immediately at the tunnel exit on the Rhône side.

"Pumping stations are located at ITGs 2, 6 and 10. For other reasons relating to the organisation of works and worksite phasing, these were widened from a diameter of 3.3m to 6.2m, allowing site traffic to pass through. The clear water pumps were designed to cater for estimated water ingress levels. For the wastewater network, the pumps were designed on the basis of the regulatory rate of 100l/s which applies in the event of an incident in the tunnel"

References

- Clayton, E., Soler, B., Voiron, J., *Major renovation of Croix-Rousse tunnel – specific aspects of the technical design* (Congres International de Lyon, 2011)
- Lopez, F., Martin, F., Pangioni, T., *Control of vibrations in the urban environment – Excavation with explosives of the North Tube of the Croix Rouse Tunnel*. (Swiss Tunnel Congress, 2012)
- UK House of Commons Select Committee, *Report on the Silk Trade with The Minutes of Evidence an Appendix and Index* (1832)
- www.tunnelcroixrousse.fr

of pumping, writing: "The chosen solution in the project phase has consisted in splitting the Southern tubes into three sections of the same length (approximately 600m), each centred on a low point located at an ITG, where pumping stations for clear water and greywater pump the water to the Northern tube drainage network. This

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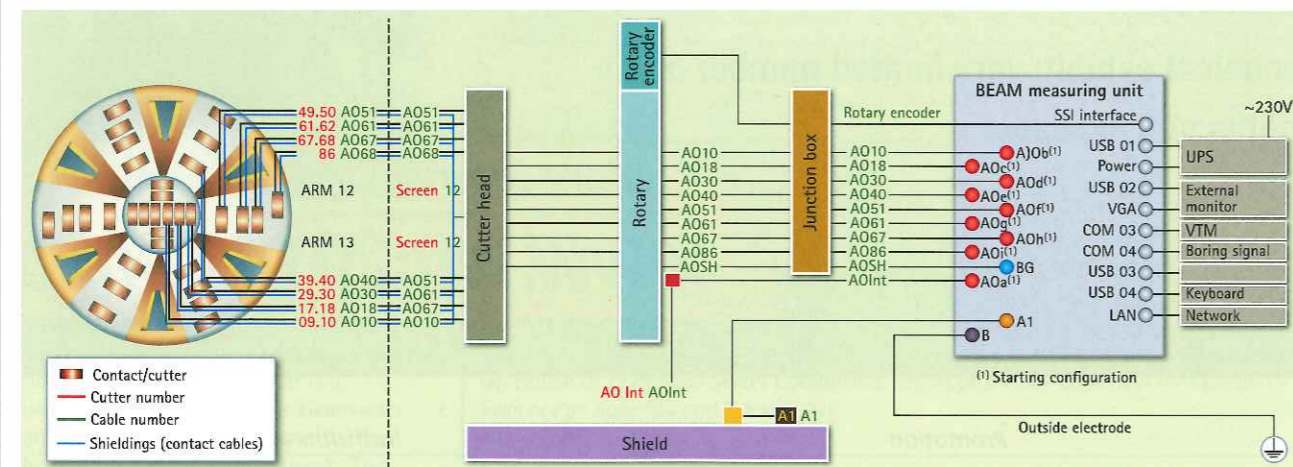


SHAKE AND BAKE - SEISMIC AND GEOELECTRIC PREDICTION

Tucked in a corner of Bauma 2013, Geo Exploration Technologies set up their stand to showcase Bore Tunnelling Electrical Ahead Monitoring (Beam). The geoelectric system, developed a decade on from the introduction of geo-seismic predictive technology to the tunnelling industry, has a few key advantages claimed, while Amberg's offering of Tunnel Seismic Prediction gets a revamp. **Alex Conacher** reports

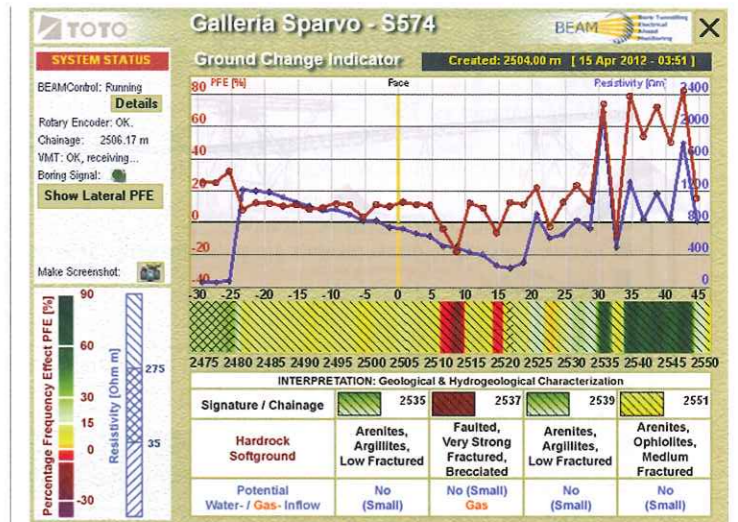
AS CHRISTMAS 2013 approached, the 17.5m Hitachi Zosen EPBM on the SR99 project in Seattle received an unwelcome present as it advanced into an unknown obstruction and stopped in its tracks. Washington State Department of Transport (WSDOT) programme administrator Todd Trepanier told local press that the world's largest TBM wasn't stuck, but had been halted by a mystery obstacle, later identified as an 8in (200mm)-diameter pipe after difficult probing.

Alex Conacher
The *Tunnels* deputy editor has been with the magazine since 2010



Right: Beam display readouts from the Sparvo project in Italy

Opposite: Circuit board style diagram representing Beam physical setup



Dewatering wells were sunk, the ground was improved and any voids stabilised, and then a 1.5m-diameter vertical bore from the surface removed the pipe debris.

Arguments rage over the cost of the delay, and responsibility for it.

Meanwhile, local media lampoons the tunnelling industry's biggest new toy, and the engineers in control, for being stopped by so tame an impediment.

Standard geotechnical investigations can only do so much - exploratory drilling from the surface or into the face can only tell geologists the nature of the rock in the boring diameter. In addition, surface geotechnical investigations are limited by topography, while exploratory drilling from the tunnel face is another delay, and cautious, extensive probing even more so. A risk-balancing act ensues: whether the contractor advances tentatively, assuming the worst and carrying out extra investigations at a cost, or act in accordance with the known data from geotechnical surveys.

There are options to mitigate this. Real-time and semi-real-time geotechnical prediction technologies allow advance to continue relatively unabated, without having to "drive blind".

LOOKING BACK AND SEEING AHEAD - THE BIRTH OF GEOLOGICAL PREDICTION

It all started, according to Amberg Technologies' geophysics business unit manager Thomas Dickmann, in Switzerland in 1990 with early geological investigation work on the 21km Vereina Tunnel.

The demands placed on the engineers for forecasting technology led to the early development of the company's Tunnel Seismic Prediction (TSP) technology for detecting geological discontinuities ahead of the face.

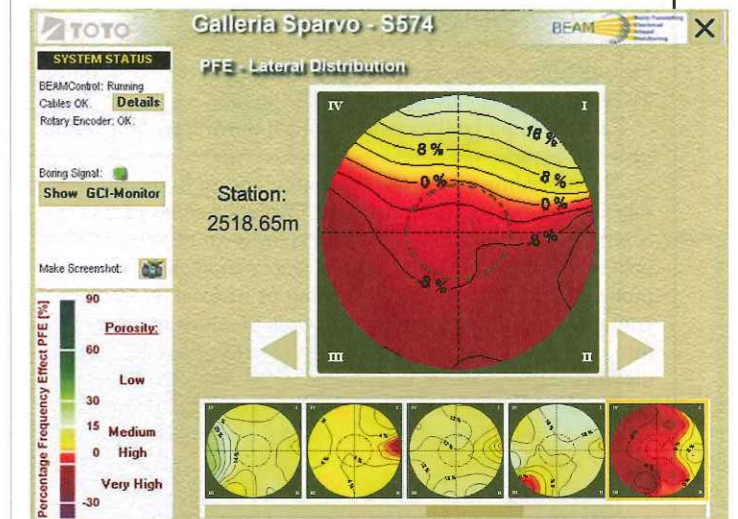
The year 1994 saw TSP 202 launched, a precursor to TSP 203 in 2001 which featured three-component signal reading, and allowed the evaluation of both P and S waves.

This meant rock mechanical parameters such as Poisson's ratio, bulk and shear moduli, and Young's modulus of the rock ahead was available to the contractor. Last year, the company unveiled its '3D' system, TSP 303.

This newest system integrates 3D data acquisition and processing software, containing routines for optimal seismic imaging with respect to tunnelling requirements.

It exploits the information in the seismic wave field by separate compression (P) and shear (S) wave analysis and the 3D-Velocity based Migration & Reflector Extraction technology (3D-VMR).

The 3D-VMR technology provides an adequate and detailed 3D image of the ground leading to a more reliable interpretation compared to conventional 2D approaches (Dickmann and Krueger, 2013).



Thomas Dickmann

Thomas is head of the geophysics department within Switzerland-based Amberg Technologies. He will be presenting on the topic of geological prediction at WTC 2014 in Brazil



Arnim Kaus

Arnim is managing director of Geo-Exploration Technologies and originally patented the Bore-tunnelling Electrical Ahead Monitoring system, better known as Beam



Wolf Boeing

Wolf is a partner of Arnim Kaus and with him leads Geo-Exploration-Technologies and its 10 geophysical engineers. His own background is in economics



BEAM compared with TSP - Amberg's assessment

BEAM advantages vs. TSP

- Continuous measurement during advance.
- Less bore holes in tunnel wall required; easier to operate when in shielded TBM w/ precast segment lining
- Can operate in EPB-TBMs (softer ground)
- Electrical resistivity measurements are suited for water detection
- Cost-efficient

BEAM disadvantages vs. TSP

- Applicable only in TBM advance; TBM needs to be prepared for the operation.
- Range: 3x tunnel diameter, rather shorter than TSP, which gives 150m+
- No spatial location of geologic discontinuities
- Ambiguous interpretation of measuring data can lead to fatal mistakes.
- Scientific background of the methodology is questionable among some experts.

SOUND PRINCIPLES

Given the limitations of probe/core drilling as an investigative measure, there was a need for a wider field, deeper-penetrating assessment of geology in advance of the face.

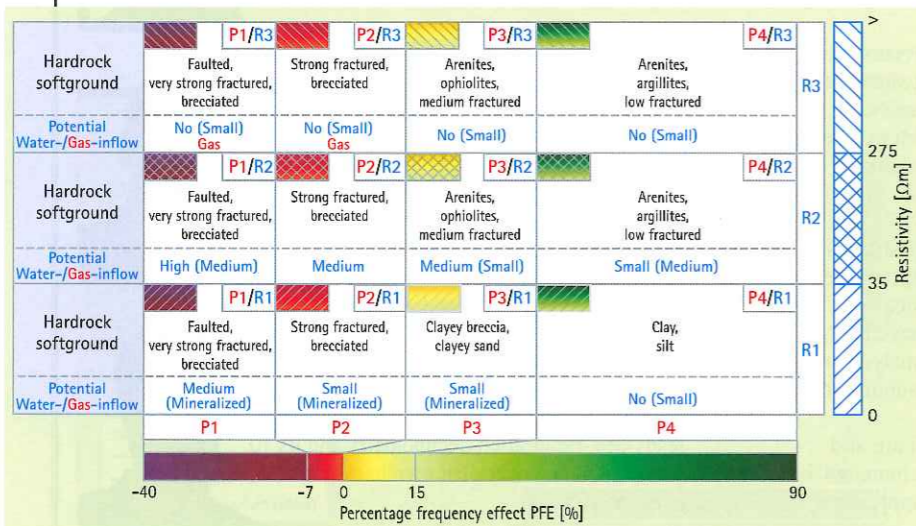
...If this could be done with minimal downtime, that would be a key bonus.

The procedure takes 60-90 minutes, and so is ideally taken in brief production breaks. It involves a series of 24 'shots' containing 0.025-0.1kg of explosive to be set off behind the excavation face, which causes an acoustic wave to project. Four sensor probes consisting of tri-axial receivers are contained in protection tubes, the ends of which are cemented into boreholes of 45-55mm in both sidewalls. These detect discontinuities in the return wave - which are caused by geological interface-caused reflections - and pass the data to an evaluation software package. Results are apparent within a matter of hours.

On the small bores required, Dickmann muses, "The use of a precast segmental lining does mean a restriction for seismic surveys, since the rock mass isn't accessible at all. In order to avoid large-scale drilling measures through the segments, it's helpful to use the grouting and lifting inserts [for shot or receiver boreholes]."

The company states that as long as segments are 300mm thick, there is no chance of a stability issue. Induced loads from blasts are momentary and there is only a chance of small fissures.

Below: Beam cross correlation matrix between percentage frequency effect and resistivity for hard rock classification and water inflow estimation



"Aside from the long standstills that can be avoided through risk reduction, **advance rate increases are also possible.**"

Regarding the analysis of returning waves, Dickmann adds, "Elastic body waves passing through homogeneous, isotropic media have well-defined equations of motion.

Utilising these equations, computations for the wave speed may be uniquely determined. Field surveys can readily obtain wave velocities, Vp and Vs; velocities are in units of length per time, usually meters/second (m/s). A homogeneous, isotropic medium's engineering properties of Young's or elastic modulus (E) and shear modulus (G) and either density (ρ) or Poisson's ratio (ν) can be determined, if Vp and Vs are known.

"The units of these measures are: moduli in pressure, usually Pascal (Pa); density in mass per volume, grams/cubic centimetre (g/cm3) and, ν, dimensionless.

$$\nu = \frac{[(Vp/Vs)^2 - 2]}{2[(Vp/Vs)^2 - 1]}$$

$$E = \frac{rVp^2(1-2\nu)(1+\nu)}{(1-\nu)}$$

$$G = \frac{E}{2(1+\nu)}$$

$$\rho = \frac{G}{Vs^2}$$

"Density ρ can be determined from samples or from boring samples or downhole logging. Estimates may be assumed by material type. Laboratory values may be offered of all these parameters, but field values will vary considerably from the lab estimates, because intact rock behaves differently to rock mass in-situ."

PASSIVITY AT ANY PRICE (A NON-PERCUSSIVE OPTION)

Bore Tunnelling Electrical Ahead Monitoring, better known by its acronym Beam, was patented in 1998 and has been in use on projects, in various forms, since the Löttschberg base tunnel in 2000.

As with TSP, Beam targets the main geotechnical problems of TBM tunnelling, i.e. the sudden occurrence

of unexpected high porosity ground (e.g. cavities, karst rocks, fault/fractured zones, and coarse material).

Aside from the long standstills that can be avoided through the reduction of major risks, advance rate increases are also possible through the reduction of probe drilling occurrences, and also prior warning of the nature of ground to be traversed allows for optimal tunnelling practice to be adopted.

BEAM METHOD

Beam combines the principles of focusing electrode logging (Davies et al, 1992) (Schlumberger, 1972), and frequency domain induced polarisation (IP) measurements [5]. Low frequency alternating electrical fields are generated by galvanic injected currents through an excavation-specific focusing electrode configuration.

The electrodes being either the cutter wheel as a giant measuring electrode in the basic 'BEAM Integral' package, or additional cutting tools being adapted as electrodes in the further 'BEAM Scan' package. This allows more detailed imaging of 2D and 3D targets, as well as an advanced lateral resolution ability.

By adjusting the same voltage of the same polarity simultaneously between the guard electrode A1 (+) and the return electrode B (-), and between the measuring electrode A0 (+) and the return electrode B (-), the measuring current is forced ahead of the face, even if the electrode resistance between A0 and A1 is very low [3].

Therefore the realised constant measuring conditions of applied frequency dependent voltage U (f) and electrode configuration cause the magnitude of the sensed measuring current I0 (f) to be solely influenced by the electrical properties of the ground. Thus, when the tunnel face is advancing towards a ground change, I0 (f) directly images the 'coming' new geological situation. The obtained measuring parameters are the frequency dependent resistivities:

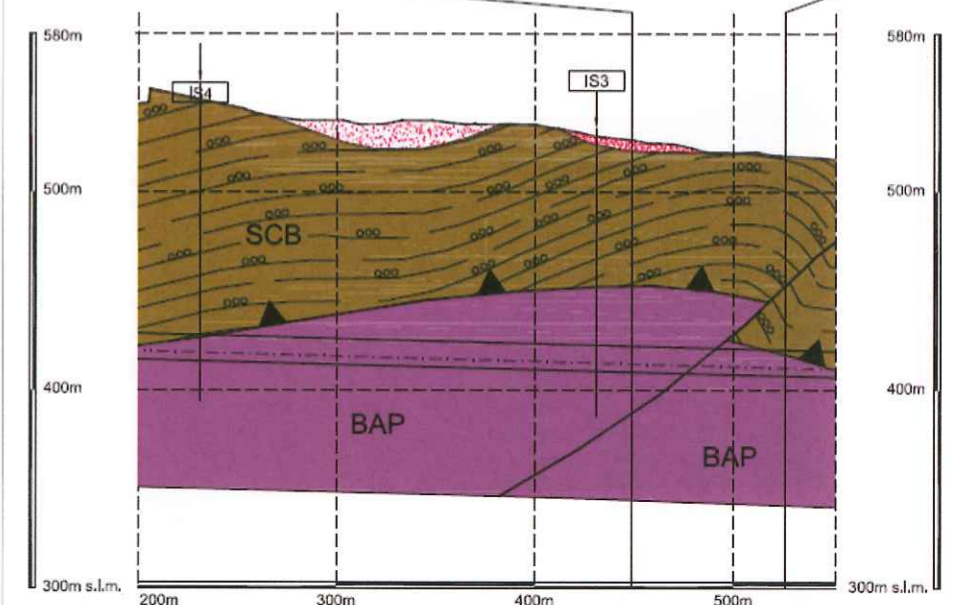
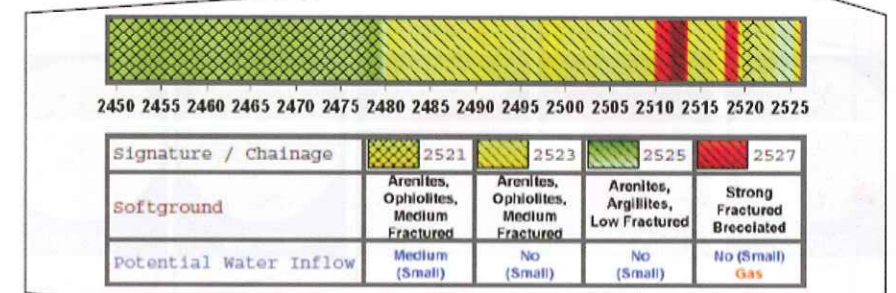
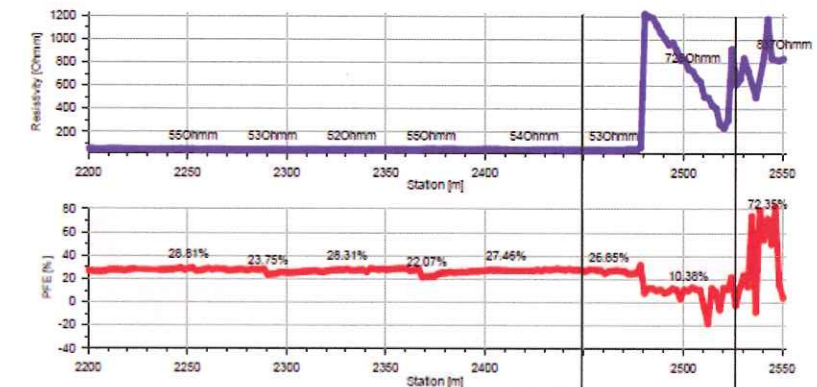
$$R(f1) = k \times (U(f1)/I0(f1))$$

$$R(f2) = k \times (U(f2)/I0(f2))$$

With:

$$K = \text{constant, and the PFE (Beam) = } 100 \times (R(f1) - R(f2))/R(f1) \text{ [%], with frequency } f1 < f2$$

For imaging the electrical field distribution around a tunnel, and forwards relative to the bore, a 3D finite element model is carried out using a software package, 'Fracture'



Above: Features of the Beam system predicting geology

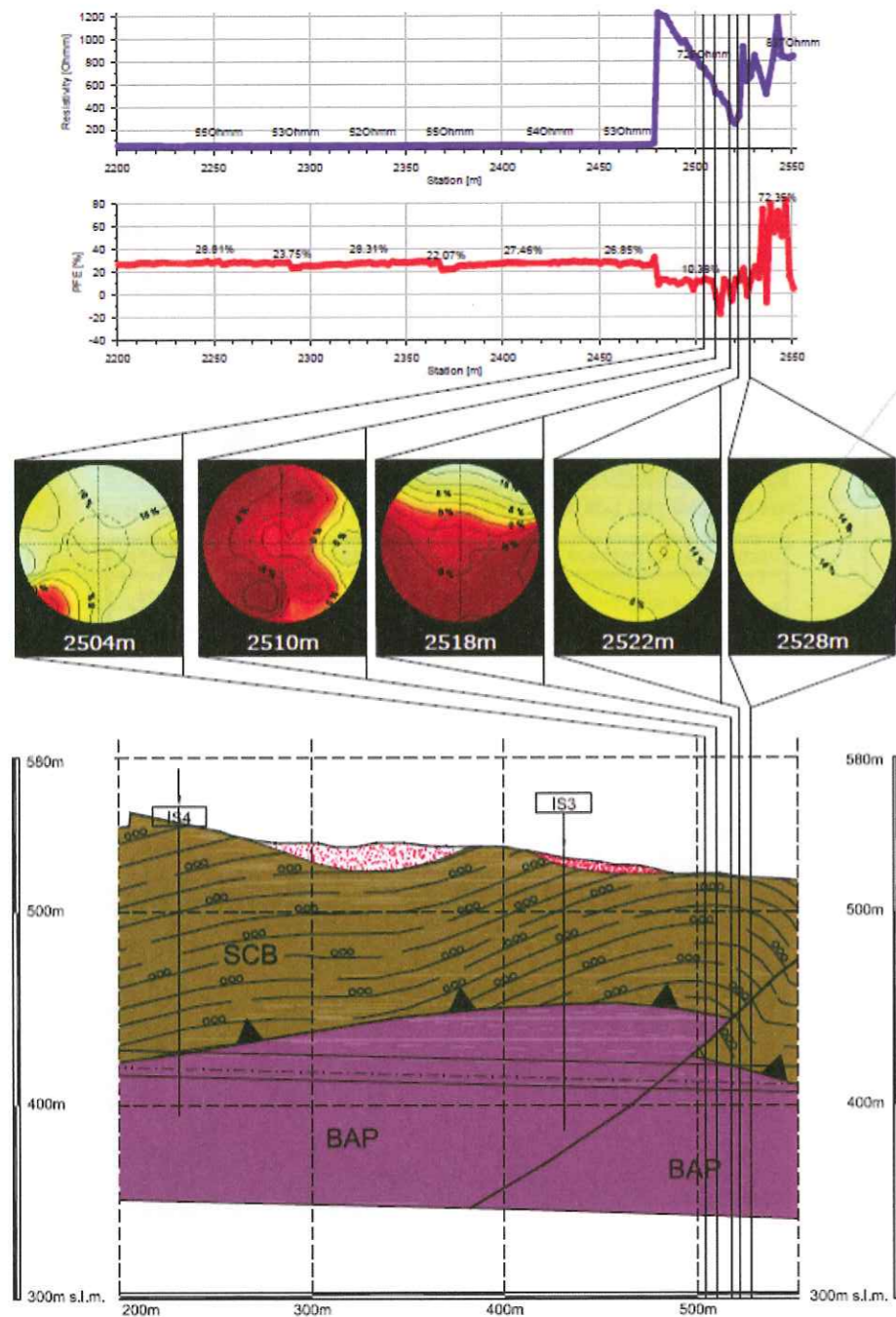
[6]. The model simulates an excavation with one measuring electrode A0 positioned on the face and the enclosing tunnel diameter large guard electrode A1 (armed lining, shield mantle) encountering different ground changes and 2D/3D targets compared to a rock mass without ground change.

The distribution of the electric field and the current vectors are presented in distances of 1 and 10m within successive sections ahead of the face.

The assessment of modelling results and geological experience from tunnel projects are indicating a distinct sensitivity zone for ground changes in a prefield distance of about three times the guard electrode A1 diameter (three times the tunnel diameter).

Components of BEAM include:

- The Beam geoelectric unit in the TBM cabin
- Measuring electrodes



- Guard Electrodes
- Return electrode

TEARS FOR FEARS

For contractors operating in hard rock, high porosity zones are of extreme relevance to the drive.

In soft ground, clay layers, sand/gravel aquifers, pyroclastics, wood, boulders, piles and archaeological remnants are of interest for excavation. And Regarding 200mm steel pipes of the sort encountered by the coastal SR99, Wolf Boening says, "[Although] in general [the] Beam real-time ground prediction system is a tool for minimising... geo-hazardous risks [in particular], of course obstacles like wood piles or metal pipes could be detectable and indicated as warning on [the] Beam screen, whereby a sufficient contrast to consisting geology is required."

Boening adds, "Our main advantages are the disadvantages

of seismic predictive systems like Amberg.

"Beam is installed only once onto any TBM type, and independent of any geology.

It performs permanent automatic high-resolution forward prediction and perimeter exploration while the TBM is boring. There is no disturbance of tunnelling work and the TBM doesn't need to stop for any measurements. Every stroke is measured and directly evaluated as well as indicated.

Beam's measuring unit is placed in the operator cabin and it has an integrated screen for indicating real-time ground prediction results ahead of the face.

"The contractor receives continuously update forecast 'pictures' at a distance of three-times the tunnel diameter ahead of the TBM. At the same time, the Beam system can be controlled from outside the tunnel by using any accredited computer for showing simultaneously forecast results. Also online maintenance, or potential online support is possible by the manufacturer (us), if required.

"When using a seismic system the tunnelling work has to stop, and also TBM needs to stop rotating during measurements. Results are not real-time and experts are needed to evaluate the data.

"In our opinion you can't achieve high advance rates with seismic systems. Modern tunnelling under time and cost pressure should use a real-time technology like BEAM, if geophysical measures are required."

BEAM CASE STUDY: SPARVO HIGHWAY PROJECT

The second largest TBM in the world was manufactured to construct a new bypass for the A1 motorway in Italy. The project will alleviate congestion on the key route between Naples and Milan in the Emilia-Romagna region.

A major project though complex conditions, such as those in the Appenines, consisting of frequent squeezing clay sections, methane presence and fault zones require a deep and precise knowledge of the geological scenarios to be face with the TBM.

The BEAM system, developed and provided by Geo Exploration Technologies (GET), was applied as a geophysical method for real-time ahead investigation continuously during the tunnelling activities.

Two operation modes are available. The integral mode is the basic system for 1D forefield exploration of resistivity

"[Although not the system's primary purpose], obstacles such as wood piles and metal pipes would be detectable"

and IP-data along the tunnel. The scan mode provides 2D forefield exploration perpendicular to the tunnel axis for lateral resolution.

System setup for high-diameter clay drive

The system setup for the Sparvo project comprises the following main components:

The BEAM measuring instrument performs fully automatic data acquisition, processing, and visualisation simultaneously for real-time data presentation including self-explanatory geological-hydrogeological interpretation. It is placed in the TBM steering cabin with cable connections from the electrodes, guidance system (VMT), the PLC (boring signal switch), rotary encoder, network internet access and uninterruptible power supply.

For the BEAM integral mode the whole cutter head is used as one large "moving" measuring electrode (A0Int) coupled to the face due to the rotational forward advancement of the TBM.

For the BEAM scan mode 8 insulated cutters are used as rotating and forward moving measuring electrodes (A0). The cables are protected inside channels and connected through an electrical rotor. Rotational electrode position is provided by a rotary encoder.

The guard electrode (A1) consists of the ground coupled TBM shield with fixed contact and cable connection for the whole drive time.

The return electrode (B) is earthed by a steel rod in a far distance to the TBM-face outside the tunnel, leaving fixed for the whole drive. Thus the B-cable has to be prolonged from time to time.

Two switchable chart screens are provided displaying measuring results of the integral mode and the scan mode.

The integral chart represents in the upper part the "Ground Change Indicator" graph along the tunnel axis with the resistivity curve and the PFE (IP-parameter) curve build-up of survey points allocated about 47m ahead of the face (3-times the Sparvo TBM-diameter).

References

Dickmann, T. and Krueger, D., *How to turn geological risk into manageable risk.* (WTC 2014 proceedings)
 Dickmann, T. and Krueger, D., *Is geological uncertainty ahead of the face controllable?* (WTC 2013 proceedings)
 Kaus, A. Et Boening, W. (2008): *BEAM - Geoelectrical Ahead Monitoring for TBM-Drives*, Geomechanik und Tunnelbau, 1. Jahrgang, Heft 5, S. 442-449

These are 'moving' stroke wise from right to left always refreshing when new data is recorded during the drive.

The actual face (yellow line) divides between forecast data and passed data.

The bar chart visualises the changing ground classification during a drive, which is based on resistivity and PFE combination classes. The attached interpretation table in the lower part is customised according to the geology of the Sparvo project.

The scan chart is based on the measuring data obtained at the rotational survey positions of the A0 cutter electrodes.

It provides forecast and passed PFE contour plots within spherical cross-sections successively aligned by a stroke wise spacing.

Because of the reciprocal relationship between both polarisation and porosity it indicates a relative porosity distribution whereby high porosity (low PFE) anomaly zones containing potentially open cavities and open fractures could be laterally located.

Application

To operate under the prevailing complex ophiolitic geological conditions a customised petrophysical classification was developed. It is based on the Beam cross correlation matrix using four PFE ranges (P1 - P4) and three resistivity ranges (R1 - R3) resulting in 12 combination classes (P/R) reflecting hard rock and soft ground, fault and fracture properties as well as water-inflow and gas-inflow potential (methane in this case).

These P/R-classes are incorporated within the dynamic bar chart using the matrix colour/hachure combination and the geological and hydrogeological characterisation within the interpretation table of the integral screen.

Resistivity and PFE measuring data which are falling into the P1/R1-R3 matrix fields are indicating the most drive-relevant faulted, fractured and brecciated zones. Clayey and weathered ground will be mainly expected in the matrix fields P3-P4/R1 and compact rock corresponds mainly to the P4/R2-R3 matrix fields.

Along the 2,500m long TBM-drive there have been several successfully early warning forecasts of critical rock sections, which have been confirmed and safely cleared up by using different geotechnical tunnelling measures

CONCLUSION

The technological improvements in passive (and semi-passive) geological predictive methods are well publicised by the suppliers, particularly in the case of TSP. And the cost as a percentage of project value, or measured against any reasonably major shutdown from geological surprises seems almost negligible.

Encouragingly, there are advantages to both systems, which seem to cover the other's disadvantages - and neither excludes the other. For mountain projects with difficult investigations conducted from the surface, both could be vital inclusions for the contractor's arsenal

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With underground infrastructure vulnerable to a number of security threats including fire and terrorist attack, SP Technical Research Institute of Sweden has established a regular tunnel symposium attracting more than 200 delegates from around the world

SAFETY ON

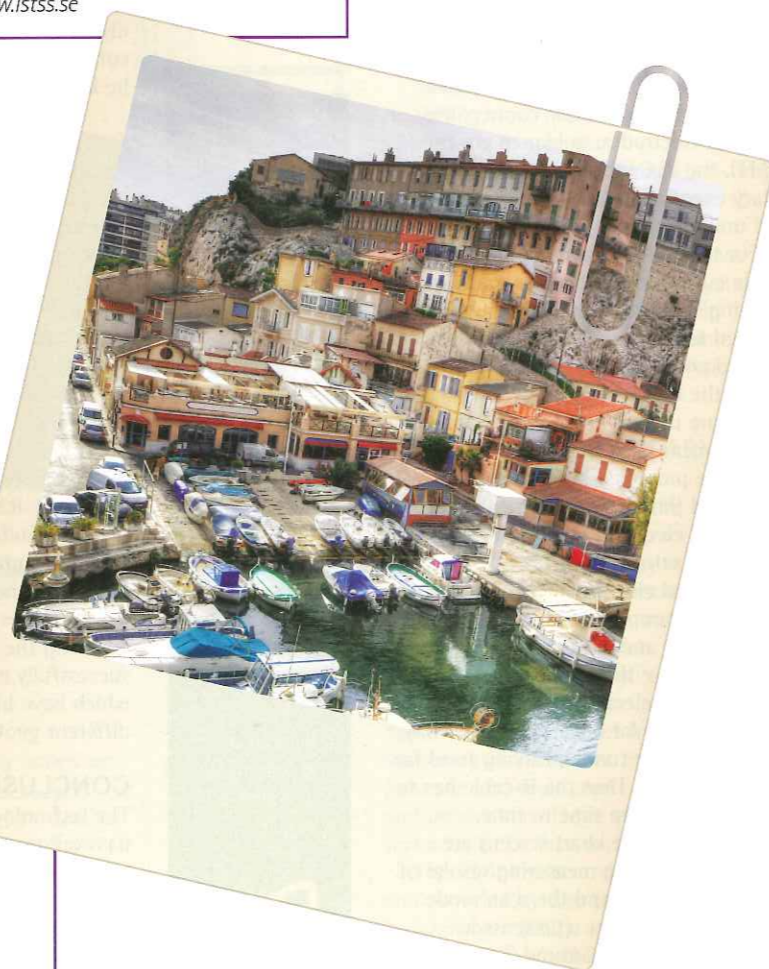
RUNNING EVERY other year, the International Symposium on Tunnel Safety and Security brings together industry professionals to explore the topics of fire and safety in tunnels. Organizers SP Technical Research Institute of Sweden says the focus is shifting more towards security since the inaugural event in 2004, and of course after 9-11 in New York.

"The new terrorist threats and focus on how to solve these problems is increasing. The need for expertise in this area for underground infrastructure in general is continuously increasing. The aim is to make ISTSS as a natural forum for scientists and practicing engineers to exchange information in the future," according to SP.

The two-day event is held in a different location each year with the 2014 event in Marseille, France. There are site visits and an additional workshop available to attendees, along with the Symposium

ISTSS 2014

12-14 March
World trade center Marseille
Provence
2, rue Henri Barbusse
13001 Marseille - France
www.istss.se



Symposium themes

- Risk & Security
- Explosions
- Human Behaviour
- Passive Fire Protection and Construction
- Active Fire Protection
- Fire Fighting and Incident Management
- Ventilation
- Fire Dynamics
- Fire Safety Engineering
- Regulations

Field trips

Axe Littoral and Prado Sud tunnels 14 March

"Axe-Littoral" through Marseille's inner city is a north-south underground link. Supporting a 40,000 vehicles a day traffic, the three two-tubes tunnels forming "Axe-Littoral" (Joliette/Major, Vieux-Port and Prado-Carenage) are key infrastructures for commuters in the Marseille area.

The "Prado Sud" tunnel consists in a new double-deck tunnel of 1,400m built using a smart "mole" technique to limit the impact at street level. This new link connecting the southern areas to highway A50 and "Axe Littoral" has been opened to traffic since November 2013.

The ISTSS 2014 technical visit will pass through "Vieux-Port" tunnel, a late '60s immersed tube tunnel that underwent a challenging retrofit ended in 2012, and "Prado Sud" tunnel and its innovating operators' training simulator.

Demonstration smoke test

The demonstration smoke test is fully booked, however there is a waiting list by contacting istss2014@kongressbolaget.se. The demonstration is by Efectis Outlabs Ventilation.

The Prado Carénage recently opened, is a 2.5km road tunnel for crossing Marseille, built from an old railway tunnel. A large-scale smoke ventilation test will be organized in this tunnel on the Wednesday evening.

L-SurF workshop 11 March

In cooperation with ISTSS 2014 L-SurF is running a workshop on new energy carriers in tunnels and underground facilities. EU policies recommend the development of alternative fuels for cars and this has an impact on underground infrastructure like tunnels. Banning cars using LNG, hydrogen or capacitors from tunnels or parking in the cities can be a major barrier for the introduction of these technologies. Ignorance, fear and emotion must not be the key drivers for such important questions.

On the contrary, if the public is reassured that manufacturers, infrastructure operators and the competent authorities have properly dealt with the safety issues, then it can be an argument to quickly market the new vehicles or energy systems. Therefore actions must be launched in a timely manner to make sure that the daily use of new energy carriers is not only consistent with the EU framework policies on climate change and energy consumption but is also safe.

Cost

180 Euro for one day workshop
110 Euro if register at the ISTSS 2014
Registration available online
www.istss.se

Keynote speakers

Peter Sturm Graz University of Technology, Austria

Sturm holds a PhD in mechanical engineering and is currently the head of Traffic and Environment at the Institute for Internal Combustion Engines and Thermodynamics. In addition he is CEO of an independent consulting service that deals with all types of ventilation technologies and fire life safety. The focus of the research work is in the field of traffic and urban air quality. A further major activity is in the field of tunnel ventilation and safety, with a focus on road tunnels.

Kees Both Promat International NV, Belgium

Both has a background in civil engineering. Both his Masters and PhD theses were taken from Delft University on fire safety of steel-concrete structures. During the almost 25 years of Kees' career in the field of fire safety, he has worked on several international projects, with a focus on tunnel safety, numerical analyses and large scale fire testing.

Magnus Arvidson SP Technical Research Institute of Sweden

Arvidson is a Fire Protection Engineer graduating from the University of Lund in Sweden in 1989. He has been working at the Department of Fire Research at SP Technical Research Institute of Sweden since 1991, mainly responsible for activities related to water mist and sprinkler system testing and research.

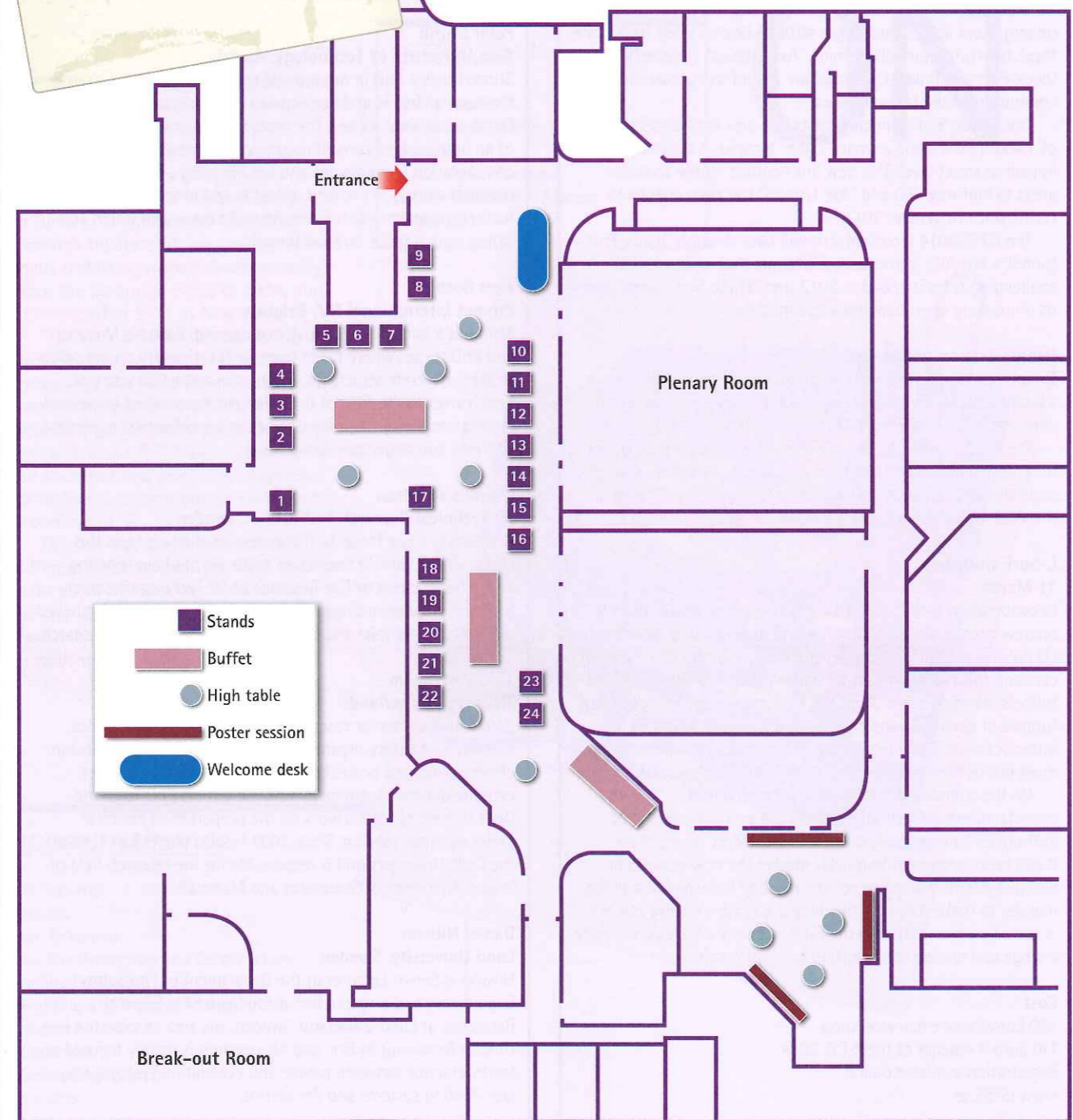
Jaap Weerheijm TNO, The Netherlands

Weerheijm is a senior research scientist at the TNO Defence, Security and Safety organisation. His expertise is on explosion effects, structural protection and material response under extreme dynamic loading. In 1992 he got his PhD from the Delft University for his work on the properties of concrete under dynamic loading. Since 2003 he also works part time at the Delft University and is responsible for the research field of Impact Dynamics of Structures and Materials.

Daniel Nilsson Lund University, Sweden

Nilsson is Senior Lecturer at the Department of Fire Safety Engineering and a researcher at the Centre for Societal Resilience at Lund University, Sweden. His area of expertise is Human Behaviour in Fire, and his research is mainly focused on the interaction between people and evacuation systems, e.g., way-finding systems and fire alarms.





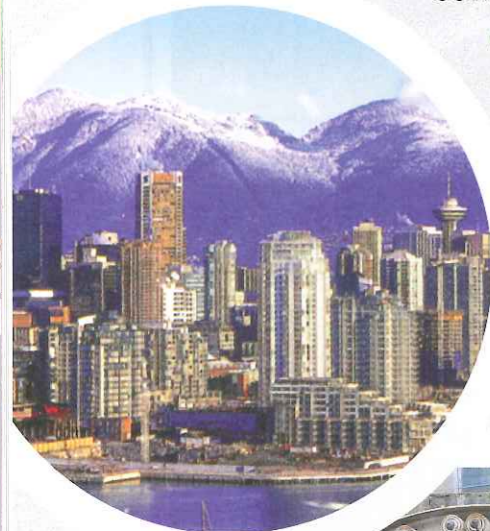
Exhibitors	
Company	Description
VID Fire Kill	VID Fire-Kill is a leading developer and manufacturer of low pressure watermist systems for active fire protection. VID Fire-Kill offers a technical, simple to install, and low maintenance tunnel fire protection system. The integrated system includes zone divided active fire protection with watermist together with double knock fire detection with addressable fire alarms. The active fire protection system operates with 10 bar water pressures and employs common available components, pumps, valves and stainless steel AISI 316L pipe systems. The full system is delivered in modules which are factory assembled and tested, for simple and fast installation and commission in tunnels. The system has been full scale tested in tunnel fires of up to 100MW, involving diesel oil and solid fuels. Exhibition stand 1
Sentio	Sentio is a new innovative fire detection system for tunnel protection. The Sentio® system consists of extremely sensitive multiple gas sensors that can endure tough environments. This facilitates extremely early detection of fire incidents as well as the suppression of known disturbances, for example diesel exhaust fumes. Sentio® is developed by Firefly AB in Sweden – the world's leading supplier of fire and explosion protection systems for the process industries. Exhibition stand 7
HBI	HBI is a firm of consulting engineers. The services focus on the design, planning and execution of projects in the field of tunnel ventilation, prediction of emissions, safety issues as well as the aerodynamics and thermodynamics of rail and road tunnels. HBI offers the entire range of services related to tunnel ventilation – from first feasibility studies, over measurements, detail studies, project execution up to refurbishment and optimization during operation. Exhibition stand 22
FLIR Systems	FLIR Systems is the world leader in thermal imaging cameras. Traffic managers all over the world use intelligent technology from FLIR Intelligent Transportation Systems to monitor and manage traffic streams. Be it for monitoring motorists and pedestrians in urban areas, for detecting incidents on highways and in tunnels, or for traffic data collection purposes, FLIR intelligent detection and monitoring solutions enhance traffic safety and mobility on a daily basis. Exhibition stand 10
FOGTEC	FOGTEC is the world leader for the design and installation of fixed fire fighting systems for underground facilities. FOGTEC supplied turnkey installations for example in the Eurotunnel, the Tyne Crossing tunnels in Newcastle and for the M25 Dartford Tunnels near London. Services include risk analysis, fire testing, design, RAMS studies, fire detection, CCTV, control systems (SCADA), fixed fire fighting systems (FFFS) and maintenance. The core of FOGTEC's activities is its team of dedicated experts originating from various fields of engineering. Exhibition stand 13
Tyco Fire Protection Products	Tyco Fire Protection Products is a division of Tyco, the world's largest pure-play fire protection and security company. Tyco Fire Protection Products manufactures and delivers an unmatched range of detection and suppression systems, extinguishing agents, sprinkler systems, valves, piping products, fittings, fire-fighting equipment and services that helps its customers save lives and protect property. The Tyco tunnel fire protection system is a solution specifically engineered for fire protection challenges in tunnels. Exhibition stand 11
Fermacell Aestuver	Fermacell Aestuver, one of the leading brands in glass fibre reinforced concrete (GFRP) technology, offers a wide choice of solutions for fire protection, for example, in subterranean traffic infrastructure. Aestuver fire protection boards are non-combustible, cement-bonded, lightweight GFRP boards for highly specialized applications. They are waterproof and frost-resistant, as well as extremely pressure-resistant, bend-proof and abrasion-resistant. Exhibition stand 17
Systemair	Systemair, world-wide leader for the manufacturing and commercialization of ventilation system, based in more than 40 countries, has been operating for years also in the field of infrastructure ventilation. The MRT division was created with the purpose of following actively this particular market so to supply ventilation systems for underground applications as, metros, road, train and hydraulic tunnels. The staff, with a specific knowledge for these applications, follows each project with competence and care. Exhibition stand 8
Citilog	Citilog is a world leader for Video Detection Systems. Applications include: Automatic Incident Detection – Tunnel & Bridges safety and security – Intersection control – Traffic data collection – Ramp metering – Advanced video Surveillance. Citilog's VisioPaD is the only Video Detection system without setup or calibration. It operates on existing cameras, fixed or PTZ even without preset. Over 300 highways, tunnels and bridges worldwide rely on Citilog systems for their Safety and Security. Citilog has supplied Video based Incident Detection systems for the 4 New York City tunnels, Melbourne City link, Mont-Blanc tunnel, Millau viaduct, Shanghai tunnels and other prestigious road infrastructures worldwide. Exhibition stand 3
Promat	Promat leader in passive fire protection provides sustainable passive fire protection systems, using advanced PromatX-technologies in order to protect and secure lives and values. Promat develops unique solutions for tunnel applications such as ceiling, wall, fire stopping and fire resistant doors. All these fire resistant systems are tested and approved by laboratories to make sure that all solutions provided to our customers are the best to protect and secure lives. Promat not only offers system solution but even more extensive support during planning and construction. Exhibition stand 12
Morgan Advanced Materials	Morgan Advanced Materials FireBarrier 135 is a high performance spray-applied fire protection lining for tunnels preventing explosive spalling of concrete and insulating steel structures against temperatures up to 1350°C. Exhibition stand 18

Vancouver TAC 2014

Tunnelling in a Resource Driven World

The Tunnelling Association of Canada invites all T&TNA readers and tunnelling professionals from around the world to join us from **Oct 26-28 in Vancouver, Canada** at our 2014 biennial conference **Vancouver TAC 2014**.

Our venue:
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Featuring the theme **Tunnelling in a Resource Driven World** the conference will include a comprehensive trade show, daily plenary presentations, and technical sessions in the following areas of interest:

- Aging Tunnels and Tunnel Maintenance
- Baseline Reports and Contracts
- Mechanized & Conventional Tunnelling
- Shafts
- Site Investigation and Design
- Tunnelling and Hydroelectric Projects
- Tunnelling and Mining
- Tunnelling for Pipelines
- Tunnelling in Glacial Deposits
- Tunnelling in Remote Locations and Extreme Climates
- Urban Tunnelling and Underground Space

Look for full details about the tentative Vancouver TAC 2014 conference program at www.tac2014.ca – delegate registration is now open and packages are available for only \$600 CAD. Trade Show and Sponsorship opportunities are available!

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THE OPERATOR IN CONTROL

An awareness of internal and mental processes relating to stress and fatigue is important when preparing for how people will react in a crisis situation. In an unusual twist, Allard Klok, project leader and trainer - tunnelling at Trainingproducties looks not at tunnel user behaviour, but operator behaviour when the pressure is on

OVER THE last 25 years much research has been conducted into incidents and disasters in tunnels. After the serious disasters in the Mont Blanc Tunnel (1999) and in the Kitzsteinhorn tunnel (2000), many improvements in tunnel safety were carried out. These improvements are mainly within the technical aspect of tunnel safety: detection systems, ventilation and escape possibilities for users have been improved and measures and procedures for operators have been revised. ▶

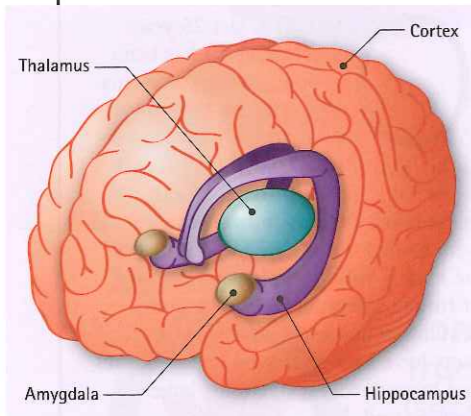
The research also looks carefully at the role of the tunnel operator (hereafter called "operator") and the role of the road user. Insight into the action and inaction of the road user has led to many adjustments to procedures and protocols. The role of the operator has been carefully studied and analysed. In the procedures that help the operator in preventing incidents, important points of improvement have surfaced and been implemented in the operator protocols. This has contributed to an increased self-rescue phase and consequently to a reduction in the seriousness of incidents.

However, using elaborate and detailed procedures and protocols brings with it the risk that the operator makes mistakes. J. Rasmussen (1988) identifies three types of human failure: Skill-based, Rule-based and Knowledge-based errors. The solution Rasmussen suggests to prevent such human failure is to improve procedures and make ergonomic adjustments.

In the extensive UPTUN research by P. Papaioannou and G. Georgiou (2008) attention is paid to the role and behavior of the operator during an incident and here too the recommendations are mostly of a process-based nature. The EU research project UPSAFETY (2011) provides clear guidelines and a standard format for an Education, Training and Practice program ensuring that operators and first responders know the procedures and protocols, thus reducing the risk of human failure by first responders and operators.

OPERATOR RESPONSE

All research up until now neglected the neurophysiological process that influences decision making. This article focuses on this neurophysiological process: the subconscious process that lies at the basis of the action or inaction of the operator. This process is also the basis of stress and occurs with the operator before and during an incident



Left: The amygdala in the temporal lobe is part of the limbic system

1999

The year of the Mont Blanc Tunnel fire in the Alps

2000

The year of the Kitzsteinhorn Tunnel disaster in Austria

or calamity. It is comparable with the action or inaction of road users in a tunnel incident.

It is a process within the brain that lies at the basis of human failure. We will provide a clear insight into this process and we will describe how we successfully bring it to the attention of the operators, making them more aware of their actions and ultimately saving lives. Because this process also occurs with road users, it is of vital importance that the operator is made aware of this ever-present mechanism and of the techniques that help him to continue to function properly.

TENSION, STRESS AND THE WORKINGS OF OUR THREAT/SELF-PROTECTION SYSTEM

There are many definitions of stress. In a general sense, stress is the reaction to a stimulation that causes tension. Within the context of this research, we regard stress as a process that is caused by a stressor (the condition that triggers the stress) and it is the reason for the stress response (the reaction to the stressor).

Research by Joseph LeDoux (1998) indicates that a small part of our brain is involved in the regulation of negative emotions, the amygdala. This almond-shaped core is located in the temporal lobe and is part of our limbic system. The amygdala establishes connections between information from different sensory inputs and links these to emotions (internal stimuli). Information reaches the amygdala in two ways:

- The direct way (Low Road according to LeDoux)
- The indirect way (High Road according to LeDoux)

The direct way is shorter and therefore faster than the indirect way but, on the other hand, also gives less precise information. The direct way transmits information through the thalamus directly to the amygdala and enables us to react before we know exactly what is happening. The thalamus is our reptilian brain, the oldest part of our brain.

This primal instinct is useful for, amongst other things, defense and hunting. In dangerous situations it is of great benefit: you fight or you flee. In primitive times, when a wild animal approached, this was a useful response. However, when this system is triggered without the presence of a direct threat, the fight- or-flight response can be a hindrance (MacLean, 1990; Hanson, 2009).

The indirect way transmits information through the thalamus to the neo-cortex. The neo-cortex analyses the information before it is sent through to the amygdala. The thalamus acts as a filter for external and internal stimuli (emotions) before transmitting these to the neo-cortex, which generates a more detailed representation of the information. This process takes more time than the direct way.

This more time consuming approach takes place in a newer part of the brain, the so called neo-mammalian brain. This is the youngest and most flexible part of our brain, where development and adaptability reside. The processes of analysis, insight, learning and development take place here.

As soon as we spot danger, the amygdala engages the hypothalamus, which in turn tells the pituitary gland to produce stress hormones. These hormones prepare the body for fight or flight. Physically, this manifests itself in an accelerated heartbeat, faster flowing blood, increased muscle tension, and the quickening and shortening of breath.

CONSEQUENCES OF STRESS

The hypothalamus also activates the sympathetic nervous system. The sympathetic nerves are responsible for the production of adrenalin. This adrenalin makes your heart beat

faster, causes you to sweat and energy to be directed to your arms and legs. This is necessary to flee or fight.

When stress is prolonged, or presents itself too often, it will cause you to slowly exhaust yourself. The body is literally in a constant state of readiness for fight or flight. The produced adrenalin cannot drain off and tension builds. This causes an unhealthy and unnecessary tension, which can eventually lead to burnout.

LEARNING ABILITY AND STRESS

Our body is an intelligent system. Many of our daily activities, some of which are quite complex, have been learned, never to be forgotten again. We are not consciously aware of many of the tasks and actions we perform regularly. Ultimately, the learned action is performed without thought. For example, the use of a computer keyboard, and tapping the keys on that keyboard, happens automatically. Nevertheless, an ingenious mechanism lies at the basis of this.

Another characteristic of our body is that it learns from experiences and remembers that which it learns. If you are in a scary situation and your subconscious impulse is to flee, then recollecting that occurrence is enough to provoke a similar physical response. Our body learns from events. This process can be observed in operators in their experiences with incidents. A simple rear end collision will, when first experienced, release stress hormones and put the amygdala to the test. During a second rear end collision our body will immediately refer to the earlier experience and adjust its response appropriately. Less stress hormones are released and we will be better able to use the information from the neo-cortex. We are more conscious of our actions and decisions.

It is possible to acquire this learning ability, which our body is already subconsciously applying, for use in unexpected situations. By putting our body in a simulated, unknown stress situation the stress reaction is brought out. Our brain is constantly communicating with itself and with the rest of our body to analyse and preserve contact with the external environment and intervene where necessary. An important element in this relationship is our internal "emergency button": fight, flight or freeze. This reaction is subconscious; we cannot turn it off.

We can train to become conscious of that subconscious mechanism. This causes an awareness of the internal process and gives the possibility to intervene earlier in the fight-or-flight-or-freeze response and to give preference to the information coming from the neo-cortex.

By being present, with full attention, in the here and now, we can remain in contact with our body (physical stimuli) and with our mind (physiological process). This insight provides the best chance to fully understand your own reaction and make a rational choice that has the most chance of providing an effective response. Man has a rational way of thinking, which functions well if it is not disrupted too much by tension that he has no way of dealing with. As soon as an event causes a disturbance, the mechanism that prepares for conflict is triggered.

For an operator who needs to function, this mechanism is not wanted.

THE MECHANISM THAT DRIVES THE RESPONSE

Emotion is a response of our brain to an affective stimulus. This manifests itself in behavior and physical reaction. These reactions can be conscious and subconscious. From an evolutionary standpoint, all emotions are useful. While our emotional life is complex, it's possible to distinguish three basic types of emotion regulation (Gilbert 2009).



Above: Training simulators

THREAT/SELF-PROTECTION

This system is activated by threat and danger. It is aimed at self-protection and survival. This system originates from our reptilian brain. The primary impulse responses fight, flight or fright stem from this system. Accompanying characteristics are: production of adrenalin, quickening of the heartbeat, blood flowing faster, breaths becoming shorter and saliva production halting. These are all signals that indicate the body is preparing for fight or flight. Reason is not functioning.

INCENTIVE/RESOURCE-SEEKING

This system is activated by desire (food, success, ambition, power). It is aimed at instant gratification. The body is focused. Physical characteristics depend on the desire that needs to be fulfilled and can include: accelerated heartbeat, increased muscle tension and an abundance of energy. The incentive/resource seeking system is concerned with one's own fulfillment and not primarily aimed at others. It causes a constant search for new challenges and costs a lot of energy.

SOOTHING/CONTENTMENT

This system is activated when other systems do not need to be. When the body does not have to be on the lookout for threats and no desires need to be fulfilled, the soothing/contentment system can be used. This system originates from our neo-mammalian brain and is concerned with safety, connectedness and well-being. The system provides, among other things, the possibility for reflection and development. Within the soothing/contentment system there is room for others and their desires and reason is functioning properly.

Within the field of the operator it is



Above: Operators trained with simulation actors and trainers

important during an incident that the contentment system can be utilised. When, on the other hand, the threat/self-protection system is activated, all symptoms that result from this system stand in the way of functioning effectively. It is aimed at self-preservation and not at helping others.

The exercises and techniques used to teach the operator awareness and attention originate from Mindfulness. Mindfulness is the awareness that comes from purposefully giving attention to things as they are, in the moment and without judgment.

PRACTICAL TRAINING MODULE

To make operators aware of their own stress and tension and the effect of that tension on their functioning capabilities, we have developed a series of exercises. The mechanisms that can occur during an incident are purposefully triggered in a simulated setting. These are discussed, analysed and experienced once more. This provides insight into the conscious behavior. In the exercise we ask the participants to focus on their own breathing, muscle tension and thoughts. This is a first introduction to one's own physical reactions in cases of tension. Next, the participants are placed apart from each other in the room. A simulation actor performs the same exercise with each participant. He stands behind the participant and approaches them, then he stands next to the participant, and finally he stands in front of the participant and approaches them from there. There is no physical contact and there is no talking during the exercise.

After this first round, we discuss what the participant has experienced and what the actor and trainer have noticed.

Each time, we discuss what the participant experienced in regards to breathing, muscle tension and thoughts. Based on the experiences, the participant is given a piece of advice to use in the next round. This advice can concern breathing, muscle tension or thoughts.

An example of such advice is: "be aware of your breathing and make sure it remains slow."

Next, we do an exercise and provide advice about becoming aware of your own breathing. Then we do the same exercises again and the participants are given the opportunity to apply the advice they have been given. In a following exercise we consciously trigger the fight-or-flight-or-fright response, thereby providing an insight into its effect on one's functioning. Operators often indicate that the exercise makes them aware of the effects of being fully present. They start to experience when tension is noticeable and become aware of the mechanism of fight, flight or freeze and experience the influence they have on their own thoughts and breathing and their ability to control them. They start acting more aware.

THE RESULTS

Relaxation

Stress awareness exercises lead to relaxation in the long term (Benson, 2000). Heart rate, oxygen use and blood lactate values (a chemical substance that, when found in high concentrations, is associated with fear, and, in low concentrations, with rest and relaxation) dropped during meditation. Long-lasting stress has a negative influence on physical and mental health that can cause lack of motivation, sick leave and even burn-out. On the short term the benefit for the operator is that the relaxed state means that the operator is able to start the incident at a lower stress level enabling him to focus on his tasks more effectively. The operator recognises rising stress levels and can respond adequately.

Thoughts

We experience about 40,000 thoughts per day. Luckily, we are not aware of each of those thoughts, but they do influence and subconsciously guide us throughout the day. Thoughts can be helpful or unhelpful. This determines whether tension increases or not. Giving guidance can prevent tension from building. For the operator this competence is valuable in two ways. The operator has a standardised job.

When everything goes well, those thoughts can direct him away from his primary tasks. Being aware of this process allows the operator consciously focus on his tasks. When an incident happens a lot of tasks have to happen in a short period of time and a lot of information is sent to the operator and create thoughts and actions that can lead to tension.

Preventing tension to rise allows the operator to stay in control.

Acceptance

No matter how well-trained operators are, how elaborate the procedures are and no matter how many difficult situations they have been through, there are always incidents and calamities that are new and different to them. Understanding how your body reacts in such an event helps the operator in controlling his reaction.

Being aware that these stressful unexpected events can happen helps the operator to stay focused. Accepting that road users and operators or other first responders sometimes will act unexpectedly allows them to act flexible and sometimes deviate from the standard procedures when it is best to support the self-rescue phase or other phases related to incident

management. Evaluating the deviations help in improving procedures.

Compassion

Stress awareness helps you focus your attention. Receiving attention gives one the feeling of being understood. Also, we often know immediately when someone is not paying attention and is occupied with something else. By focusing our attention we focus on the other person (The road user), thereby making them feel taken serious and understood.

The road user will then be more inclined to have that same attitude towards you, and will be more likely to follow instructions. Adding focused attention will increase the effectiveness of the communication. Understanding that road users can also face a primary impulse responses helps for better understanding.

Insight provides choice

Stress awareness gives insight into coping strategies and the operator's own preferred strategy. A coping strategy is the way in which one deals with stress and problems. Through stress awareness exercises insight is gained into one's own coping strategy. Through observation of internal processes, feedback from observers and advice, operators can practice developing a more effective strategy.

Frequent meditation has been proven to have effected structural changes in the medial prefrontal cortex (Siegel, 2007). This means that one develops a larger range of coping strategies and is able to choose more quickly. For the operator this means that he can quicker understand his behavior and decide to change to the contentment strategy.

CONCLUSION

Over the last few years, enormous progress has been made in the prevention and containment of incidents and calamities. Many adjustments and improvements concerning the revision of procedures and protocols have been implemented. The neurophysiological process which occurs with both the operator and the road user (that causes stress) can now be incorporated in the education, training and exercise programs of operators. These exercises determine whether an operator is able to function or not. The insight into the stress mechanism and the functioning of our emergency system is the missing link in the process to reach maximum safety.

Awareness exercises help operators develop techniques to become more aware and present. This alertness makes it possible for the operator to make a rational decision, thereby providing the greatest chance of an effective response. This is in addition to improvements in procedures and protocols that resulted from previous research. Up until now, no investments have been made into the awareness of the mechanisms that occur when an incident takes place. The insight that neurophysiology provides us with, opens a range of possibilities for operators to more effectively act during an incident.

Acknowledging neurophysiological processes helps the operator in finding a successful coping strategy for stressful situations where it is necessary to deviate from procedures and protocols. Making sure that an operator can quickly appeal to his soothing/contentment system and is aware of the consequences of the threat/self-protection system, can prevent a lot of casualties. Active training for this reduces costs and casualties on the short term. An additional long term advantage is the prevention of burnout and posttraumatic stress disorder.

The stress awareness module is recently successfully used in the Education, Training and Exercise program for

operators in the Netherlands. During this program operators gain insight in the technical tunnel system, the procedures and organisational aspects to operate and maintain a tunnel and their specific role that connects the technical and procedural systems together. In continuation courses we go deeper into the material and repeat the exercises. Apart from that, we also discuss and analyse tension awareness and the experienced primary reactions during Virtual Reality and Mono- and multidisciplinary exercises. Stress awareness has become a third pillar on which the education program is founded.

RECOMMENDATION

The regular training of the awareness of internal processes during stress, the insight into one's own primary reactions, and techniques that help in employing more effective behavior all help make operators more relaxed and effective. Our recommendation is to make these exercises a part of the operator's training and to implement refresher courses with the possibility to go deeper into the material. Organisations that incorporate this module in their training program should also give attention to the follow up of incidents through means of evaluations. Especially, during a "hot-debrief" session shortly after an incident, the operator is able to indicate how, when dealing with the process, he experienced his internal fight-or-flight-or-freeze reaction and which system (threat/self-protection, incentive/resource-seeking, contentment) was first utilised. By being aware of these physiological processes, the operator can act more effectively during an incident. This effective acting saves costs for the organisation, and more importantly it saves lives.

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What do you think? Send your views to the editor and join the debate



References

- H. Benson (2000), *The Relaxation Response*
- J. Brantley (2004), *Angst beheersen met aandacht [Using attention to control fear]*
- A. Damasio (1994), *Descartes' Error: Emotion, Reason, and the Human Brain*
- R.A. Depue, J. Morrone-Strupinsky (2005), *A neurobehavioral model of affiliative bonding Behavioral and Brain Sciences;*
- P. Gilbert (1989, 2009), *Collected works*
- T.M. Glomb (2011)
- P. Papaioannou (2008), *Human behaviour in Tunnel Accidents and Incidents Upsafety*
- J. Rasmussen (1988), *Coping with human errors through system design: implications for ecological interface design*
- D.J. Siegel (2007), *The mindful brain. Reflections and attunement in the cultivation of well-being*

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What's on

2014

World Urban Forum Seven
5-11 April 2014
Medellin, Colombia
The show for the UN-Habitat organisation. The United Nations Human Settlements Programme, UN-HABITAT, is the United Nations agency for human settlements. It is mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities with the goal of providing adequate shelter for all.
www.unhabitat.org

Samoter
8-11 May 2014
Verona, Italy
This trade show dedicated to earth moving, site and construction machinery is held every three years. In 2011, the exhibition attracted 98,000 visitors and more than 900 exhibitors (of which almost 30 per cent were international).
www.samoter.it

World Tunnel Congress 2014
9-15 May 2014
Iguassu Falls, Brazil
Organised by the Brazilian Tunnelling Committee of the ABMS (the Brazilian Association of Soil Mechanics and Geotechnical Engineering), as well as the International Tunnelling Association, and focusing on "Tunnels for Better Living", WTC 2014 will discuss and illustrate the importance of tunnels.
www.wtc2014.com.br

North American Tunneling Conference
22-25 June 2014
Los Angeles, California
The US Underground Construction Association (UCA)'s biennial tunnelling conference takes place in Los Angeles, California in 2014.
www.smenet.org

ATS Conference
17-19 September 2014
Sydney, Australia
This is the 15th Australasian Tunnelling Society (ATS)'s triennial conference and exhibit, and will be held at the Hilton Sydney Hotel.
www.atstunnellingconference2014.com

InnoTrans
23-26 September 2014
Berlin, Germany
An international platform for buyers and sellers of passenger and freight transport technology, InnoTrans focuses on railway technology. The Tunnel Construction segment will be accompanied by International Tunnel Forum featuring a series of international discussions
www.innotrans.de

Eastern European Tunnelling Conference
28 September - 1 October 2014
Athens, Greece
This is the second Eastern European Tunnelling Conference (EETC), which is a biennial regional traveling event. It aims to promote the sharing of knowledge, experience, skills, ideas and achievements in the design, financing and contracting, construction, operation and maintenance of tunnels among the countries of Eastern Europe. EETC2014 aims mainly to bring together colleagues from Eastern Europe but everyone is welcome. This year's theme is "Tunnelling in a Challenging Environment - Making tunnelling business in difficult times"
www.eetc2014athens.org

TAC 2014 Annual Conference
26-28 October 2014
Vancouver, British Columbia
The Tunnelling Association of Canada will hold its conference, Annual General Meeting and Awards at the Sheraton Wall Centre Hotel.
www.tunnelcanada.ca

2015

World Tunnel Congress 2015
22-28 May 2015
Dubrovnik, Croatia
The jewel of the tunnelling calendar heads to the Dalmatian Coast for the technical event of 2015 as WTC returns to Europe. Details to be confirmed.
wtc2015.com

RETIC
7-10 June 2015
New Orleans, Louisiana
The Underground Construction Association's biennial conference.
www.smenet.org

British Tunnelling Society
The BTS has a membership of almost 700 individual and 60 corporate members. It is one of the most vibrant gatherings of professional tunnellers in the world and traces its history back to its founding in 1971. Events are hosted at the Institution of Civil Engineers in London from 5.30pm every third Thursday of the month.

High Speed Guangzhou-Shenzhen Hong Kong Railway
20 March 2014
The Contract 824 tunnels will be formed through hard rock using drill and blast techniques over a distance of approximately 2.6km. Permanent shafts (over 90m deep) at either end of Contract 824 for the Ngau Tam Mei Ventilation Building and the Tai Kong Po Emergency Access Point. The majority of the tunnels will be twin bore single track tunnels with an internal span of 7.8m. The scheme also includes a 110m long twin track Crossover Cavern, which will have a maximum internal span of 22m and a maximum internal height of 15m.

Harding Memorial Lecture
19 June 2014
The Harding Memorial Lecture is given every second year, and the 2014 edition will be given by Donald Lamont.

C310 Thames Tunnel
15 May 2014
Riku Tauriainen, project director, Andreas Raedle, technical and risk manager, Andy Ingram, construction manager from the Hochtief Murphy JV discuss the geotechnical and tunnelling related specifics in urban tunnelling and river crossing with low overburden.

What could possibly go wrong with a site investigation in chalk?
16 October 2014
Roy Mortimer of Brighton University reviews case histories and the importance of site investigations and particularly the analysis of the results. To include case histories of good and bad practice.

Crossrail C300
20 November 2014
A project report of the works on the 'Western Tunnels' contract of London's Crossrail project. Speakers to be confirmed.

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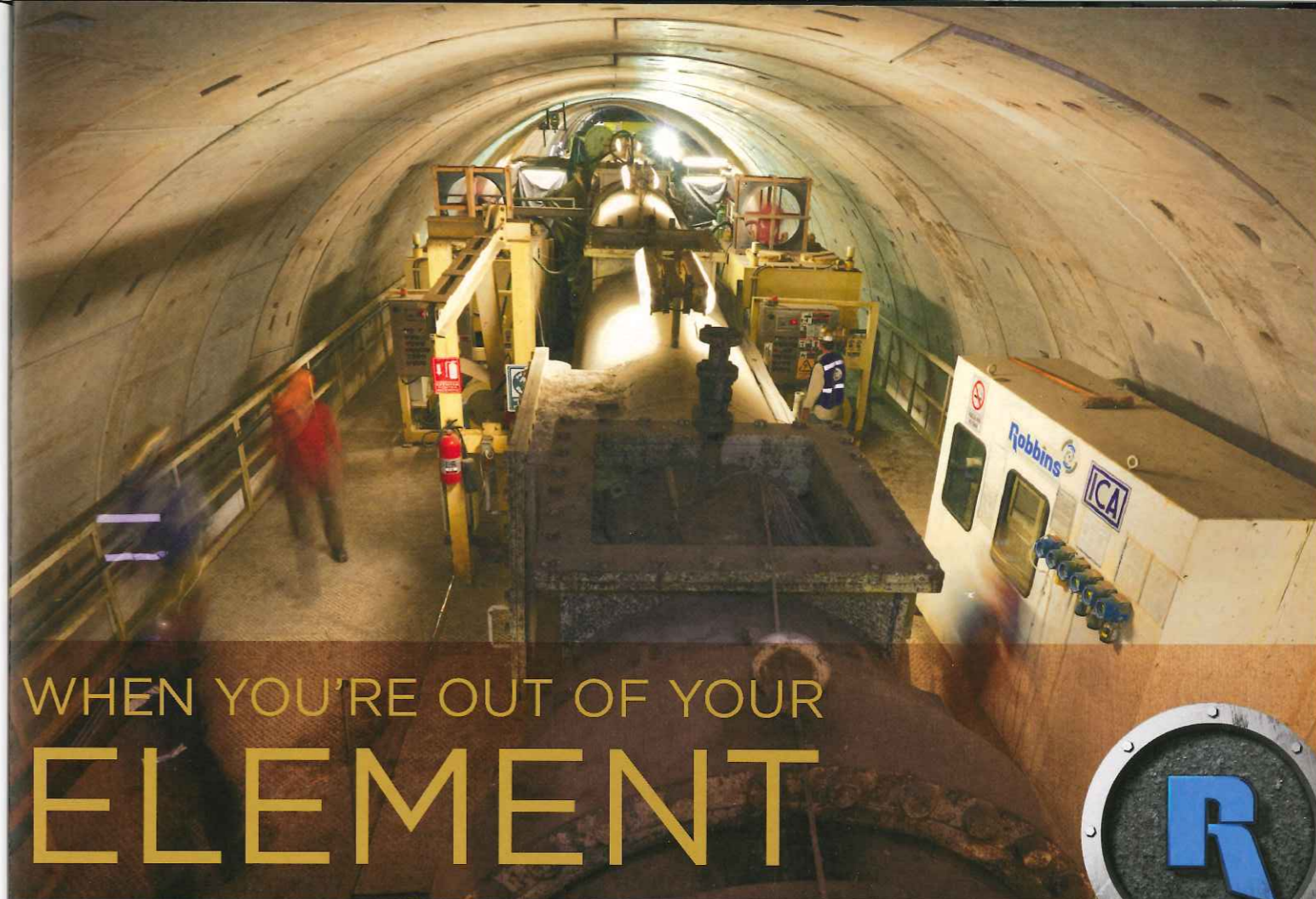
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